UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFTEY
AND POLLUTION PREVENTION

October 28, 2021

Mr. Erik C. Baptist
Wiley Rein LLP
1776 K Street, NW
Washington, D.C. 20006

Dear Mr. Baptist:

Thank you for your letter of July 12, 2021, to the U.S. Environmental Protection Agency (EPA) on behalf of the Lithium Ion Cell Manufacturers' Coalition (Coalition) regarding risk management of n-methylpyrrolidone (NMP) under section 6 of the Toxic Substances Control Act (TSCA).

EPA appreciates the ongoing engagement and communication from the Coalition throughout the TSCA risk evaluation and risk management process for NMP. Input from stakeholders is vital and EPA considered the information submitted by the Coalition in understanding the use of NMP in lithium ion cell manufacturing. EPA used this information in the final risk evaluation and supplemental information documents on the occupational exposure assessments and risk calculations. EPA used the Coalition's information on work activities, full-shift air concentration data, task duration of contact with liquid and exposure to revise and expand the modeling and add "what-if" supplemental calculations used in the risk evaluation. EPA did not rely on the what-if scenario from the Coalition's data alone to determine the unreasonable risk; rather, EPA determined central tendency and high-end margins of exposure (MOEs) based on the Agency's standard approach and methodologies for occupational exposures. In the case of lithium ion cell manufacturing, the standard approach and methodology to assess occupational exposures were used to address uncertainties regarding worker dermal contact duration data, and to account for other public data received and data from similar exposure scenarios.

EPA disagrees with the Coalition's statement that, "the Agency's own analyses did not find unreasonable risk associated with [the Coalition's] *actual* use of NMP." The risk evaluation determined there is unreasonable risk to workers of non-cancer effects from acute inhalation and dermal exposures at the high-end, and from chronic inhalation and dermal exposures at the central tendency and high-end for NMP in lithium ion cell manufacturing, even when assuming use of personal protective equipment (PPE). Though the what-if scenario MOEs were not presented in the final risk evaluation document, EPA calculated them in the supplemental risk calculation file and the MOEs for five of the six tasks are below the benchmark from chronic inhalation and dermal exposure at the high-end, even when assuming use of PPE (Rows 356-451 in the chronic worker tab of the supplemental file on occupational risk calculations). (See:

https://www.epa.gov/sites/default/files/2020-12/16._nmp_supplemental_information_file_on_occupational_risk_calculations_0.xlsx)

EPA understands the importance of domestic manufacturing of lithium ion cells and resilience of critical supply chains for equipment such as electric vehicles. As required by TSCA, EPA is currently developing risk management options to address the unreasonable risk identified for NMP. The Agency appreciates the information provided by the Coalition and welcomes the opportunity to learn more about industry safety standards and worker protection measures during lithium ion cell manufacturing. EPA is committed to understanding current practices that companies are able to take to protect their workers as the Agency considers regulatory options in the risk management phase. EPA also welcomes information regarding effective risk management solutions for NMP (including engineering and administrative controls), the extent to which lithium ion cell manufacturing relies on the availability of NMP, and any experience the industry has with alternate chemicals that perform similarly to NMP. The team developing the risk management options for NMP would be pleased to meet to discuss current practices.

The Agency will consider the information submitted relating to the Coalition's alternate request that EPA grant a TSCA section 6(g) use exemption, along with other available regulatory options, as it moves forward in the rulemaking process. At this time, EPA is not prepared to provide any information on exemptions or developing risk management options beyond what was included in the Spring 2021 Regulatory Agenda. The Regulatory Agenda entry for the NMP rulemaking can be found on the Office of Management and Budget's website: https://www.reginfo.gov/public/do/eAgendaViewRule?pubId=202104&RIN=2070-AK85.

Thank you again for your letter. If you have further questions, or would like to schedule a meeting, please contact Clara Hull by email at hull.clara@epa.gov or by phone at (202)564-3954.

Sincerely,

MICHAL FREEDHOFF

Digitally signed by MICHAL FREEDHOFF
Date: 2021.10.28 14:43:42 -04'00'

Michal Freedhoff, Ph.D.
Assistant Administrator

Tue Jul 13 08:18:48 EDT 2021
EPAExecSec <EPAExecSec@epa.gov>
FW: Letter from the Lithium Ion Cell Manufacturers' Coalition on EPA's Upcoming TSCA Regulations for NMP
To: "CMS.OEX" <cms.oex@epa.gov>

Reading file

From: Baptist, Erik <EBaptist@wiley.law>
Sent: Monday, July 12, 2021 4:50 PM
To: Regan, Michael <Regan.Michael@epa.gov>
Cc: Freedhoff, Michal <Freedhoff.Michal@epa.gov>; Hartman, Mark <Hartman.Mark@epa.gov>; Sheehan, Eileen <Sheehan.Eileen@epa.gov>; Hull, Clara <hull.clara@epa.gov>
Subject: Letter from the Lithium Ion Cell Manufacturers' Coalition on EPA's Upcoming TSCA Regulations for NMP

Dear Administrator Regan:

Attached please find a letter from the Lithium Ion Cell Manufacturers' Coalition on EPA's upcoming TSCA Section 6 regulations for n-methylpyrrolidone (NMP).

We appreciate EPA's continued engagement on this critical issue for us and look forward to continuing our conversation with the Agency.

Best regards,

Erik

wiley

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July 12, 2021

VIA E-MAIL

Hon. Michael S. Regan
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Re: Lithium Ion Cell Manufacturing Under EPA's Upcoming TSCA Regulations for NMP

Dear Administrator Regan:

The Lithium Ion Cell Manufacturers' Coalition ("Coalition") is writing to you, through its counsel Wiley Rein LLP, to share its thoughts on the upcoming Toxic Substances Control Act ("TSCA") Section 6 regulations for n-methylpyrrolidone ("NMP") by the U.S. Environmental Protection Agency ("EPA" or "Agency").

As you know, lithium ion cells are used in many products that rely on rechargeable battery technology, such as electric cars, energy storage, medical devices, portable electronics, defense systems, and aerospace applications.[1] The Coalition is comprised of entities that manufacture and rely on lithium ion cell technology, and the trade associations that support these industries: The Alliance for Automotive Innovation, EnerSys, Integer, Panasonic, PRBA – the Rechargeable Battery Association, and Saft America.

At the outset, the Coalition would like to express our sincere appreciation for EPA staff's continued willingness to engage with us. We write today as part of that ongoing engagement. Specifically, the Coalition submits a proposed path forward as EPA looks to issue TSCA Section 6 rules to address the findings in the final risk evaluation for NMP.[2] The Coalition urges EPA to adopt our industry standards as the regulatory standards—especially given that the Agency's own analyses did not find unreasonable risk associated with our *actual* use of NMP in our manufacturing processes. In the alternative, EPA must grant our industry an exemption under TSCA Section 6(g) to allow for the continued domestic manufacturing of lithium ion cells, which is necessary to achieve the Biden-Harris Administration's key priorities of electrifying the vehicle fleet and transitioning our power sector to renewable energy. It is critical for EPA to understand that any unduly and unnecessary restrictions on our ability to use NMP would jeopardize the future of domestic lithium ion cell manufacturing and impede the growth of the requisite rechargeable battery technology in the United States.

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[1] A "cell" is the technology used in rechargeable batteries (which are comprised of one or more cells). Oftentimes, cells are manufactured in different facilities than batteries. NMP is used in the cell manufacturing, not the battery assembly, process.

[2] Final Risk Evaluation for NMP, https://www.epa.gov/sites/production/files/2020-12/documents/1_risk_evaluation_for_n-methylpyrrolidone_nmp_casrn_872-50-4.pdf.

Use of NMP in Lithium Ion Cell Manufacturing

In the manufacturing of lithium ion cells, NMP is mixed with powder chemicals in a slurry. This slurry is then coated onto thin metal foil in a precise, automated roll coating process used to create a cell cathode electrode. NMP serves as a carrier for the binder resin in the slurry. The functional role of the binder resin is to hold the active material particles together for the cathode and anode, respectively. The coated foil then passes through dryers where the NMP is recovered. NMP does not remain in or on the lithium ion electrode or the final cell after the drying stage of the electrode manufacturing process. In other words, NMP is not a final component in lithium ion cells.

Lithium ion cells are produced in a tightly controlled manufacturing environment, and closed process piping systems are used for NMP transfer to prevent contamination of electrode slurry. Our industry requires strict control of potential contaminants and humidity/dew point conditions to assure a high-quality final product. Thus, manufacturers expend considerable effort to prevent human contact with NMP or electrode slurries—through the use of both engineering controls and personal protective equipment ("PPE"). Because of the need for absolute purity in our processes, nowhere in a commercial lithium ion cell manufacturing process are workers allowed to immerse their hands in NMP or NMP-based slurries—regardless of PPE.

It is critical for EPA to recognize that there is no substitute for NMP in our manufacturing processes. Lithium ion cathode cells cannot be manufactured without NMP. Indeed, NMP remains the liquid of necessity for producing state-of-the-art, high-energy-density cathodes.

EPA's Draft Risk Evaluation for NMP

EPA's draft risk evaluation for NMP found an unreasonable risk for the following exposure scenarios associated with lithium ion cell manufacturing:

- Small container handling;
- Virgin NMP truck unloading; and
- Waste truck loading.[3]

For these scenarios of dermal exposure to liquid, EPA assumed one-hand central tendency or two-hand (high-end) skin surface area exposure. EPA acknowledged that it lacked data regarding the duration of dermal contact with the liquid product. The Agency assumed exposure durations ranging from 4 to 12 hours.[4] The effect of these assumptions was to simulate *complete immersion* of one or both hands (with and without the use of protective gloves) into liquid NMP for hours. Based on these assumptions, EPA arrived at its draft determination that NMP presented an unreasonable risk during lithium ion cell manufacturing.

Coalition's Comments and Information in Response to Draft Risk Evaluation for NMP

Because these scenarios were not representative of the actual, real-world conditions experienced by our workers, the Coalition submitted multiple comments and key information to

[3] Draft Risk Evaluation for NMP, pp. 292-293, https://www.epa.gov/sites/production/files/2019-11/documents/1_draft_risk_evaluation_for_n-methylpyrrolidone_110419_public.pdf.
[4] *Id*. at 102.

the Agency in response to the draft risk evaluation for NMP and to support a finding of no unreasonable risk for lithium ion cell manufacturing:

- Written comments on January 21, 2020 (Attachment A);
- Presentation to EPA on March 25, 2020 (Attachment B);
- Chart of actual, real-world parameters for EPA's modeling on April 23, 2020 (Attachment C); and
- Supplemental written comments on May 22, 2020 (Attachment D).

The Coalition's submissions demonstrated that there is no *actual* NMP exposure to our workers. Indeed, the engineering controls that we use and the PPE that we require protect our employees during the entire time NMP and other chemicals are used throughout the lithium ion cell manufacturing process.

We also provided EPA with the reality-based durations for when there is *potential* for NMP exposure during our manufacturing processes. There were significant differences between these reality-based durations and EPA's assumed times:

Activity	**EPA's Assumed Duration of Process that Incorporates NMP (Complete NMP Immersion and Exposure)[5]**	**Actual Duration of Process that Incorporates NMP (No NMP Immersion or Exposure Occurs)**
Virgin NMP Truck Unloading	4-8 hours/day	60 minutes/month
Container Handling, Small Containers	6-12 hours/day	30 minutes/month (manual transfer at small operations) 30-60 minutes/day (mixing prep. at small operations)
Container Handling, Small Containers and Drums	6-12 hours/day	30-60 minutes/month (transfer from process to drum at small operations)
Container Handling, Drums	6-12 hours/day	30 minutes/month (transfer from drum to loading waste truck at small operations)
Cell Manufacturing, Batch mixing[6]	4-8 hours/day	2-6 hours/day (batch coating and drying at small operations)

[5] *Id*. at 102.
[6] Final Risk Evaluation for NMP, p. 152, https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/final-risk-evaluation-n-methylpyrrolidone-nmp.

		12-hour shifts (batch mixing at large operations) 12-hour shifts (batch coating, drying, and NMP recovery at large operations)
Maintenance Activities	6-12 hours/day	60 minutes/month
Occupational Non-Users	N/A	60 minutes/month

When NMP is incorporated in the manufacturing scenarios above, there is no exposure to our workers. In addition to the engineering controls that we described in our submissions, our comments provided information about the PPE that we require our workers to use when NMP and other chemicals are being used or handled. We told EPA that we base our selection of protective glove materials on the recommendations of leading glove manufacturers. This glove selection is also supported by well-conducted, published studies on the effectiveness of glove materials to prevent worker exposure to NMP. Finally, we informed the Agency that we also provide robust training, prominent signage of PPE instructions in the workplace, dedicated stations to don PPE, and the use of mixing air showers before entry into secured production areas.

EPA's Final Risk Evaluation

EPA made a policy decision not to incorporate the information provided by the Coalition into the Agency's final risk evaluation for NMP and, contrary to real-world scenarios, relied on the assumption that there would be prolonged, direct dermal contact with NMP. Applying this assumption, the final risk evaluation found that the use of NMP in lithium ion cell manufacturing "[p]resents an unreasonable risk of injury to health (workers); does not present an unreasonable risk of injury to health [for occupations non-users]."[7] In particular, "[f]or workers, EPA found that there was unreasonable risk of non-cancer effects from acute (developmental) inhalation and dermal exposures at the high-end, and from chronic (reproductive) inhalation and dermal exposures at the central tendency and high-end, even when assuming use of [personal protective equipment]."[8]

Even though EPA found an unreasonable risk for industrial and commercial uses of NMP in lithium ion cell manufacturing by applying unrealistic assumptions (*e.g.*, assuming 4-12 hours of continuous contact with NMP), the Agency also ran modeling that incorporated much of the data and information submitted by the Coalition. These data and information are representative of real-world scenarios found in our operations, which range from small to large. Under these scenarios, EPA found that there was **no unreasonable risk** associated with the *actual* use of NMP in the manufacturing processes for lithium ion cells. The table below reproduces EPA's no

[7] *Id*. at 420.
[8] *Id.*

unreasonable risk finding. EPA labeled the Coalition's information as "what-if" scenarios.[9] In no instance does the "what-if" scenario (when assuming the use of gloves with a Protection Factor (PF) of 20) present an unreasonable risk by exceeding the margin of exposure (MOE)[10]:

Exposure Scenario	Exposure Level/PPE	Inhalation Characterization	Exposure Duration (per day)	Unreasonable Risk (based on MOE)?
Cathode coating	Gloves PF 20	50th	2 hours	**No**
Cathode coating	Gloves PF 20	High-end	6 hours	**No**
Cathode slurry mixing	Gloves PF 20	50th	0.5 hour	**No**
Cathode slurry mixing	Gloves PF 20	95th	0.5 hour	**No**
Research and development	Gloves PF 20	50th	2.5 hours	**No**
Research and development	Gloves PF 20	High-end	2.5 hours	**No**
Misc.	Gloves PF 20	50th	1 hour	**No**
Misc.	Gloves PF 20	High-end	4 hours	**No**
Small container handling	Gloves PF 20	50th	0.5 hour	**No**
Small container handling	Gloves PF 20	95th	1 hour	**No**
Drum handling	Gloves PF 20	50th	0.5 hour	**No**
Drum handling	Gloves PF 20	95th	1 hour	**No**

It is important to know that EPA rated the quality of the Coalition's information as "high," as characterized by the risk evaluation and evidenced in a supplemental file.[11]

Industry Standards Should Become the Regulatory Standards

Despite our disagreements on EPA's assumptions and approaches in the risk evaluation, the Coalition believes that the Agency can issue a risk management rule that both addresses the "risks" identified in the risk evaluation and acknowledges the safe use of NMP in our lithium ion cell manufacturing processes.[12] Indeed, EPA can incorporate our industry's safety standards as the regulatory standards.

We applaud Assistant Administrator Michal Freedhoff's public statements that EPA would not set redundant rules if the identified risks are easily addressed by the measures that industry

[9] EPA referred to all industry-submitted information for the modeling parameters as "what-if" scenarios. It is not clear why EPA used this term to apply to actual, real-world use of NMP. Instead, this term would be more appropriately applied to the unrealistic assumptions underlying the Agency's risk determinations (*i.e.*, "*What if* workers did not wear PPE and immersed their hands continuously in NMP for 4-12 hours/day?").
[10] Supplemental Information File on Occupational Risk Calculations, rows 919-1038, https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/final-risk-evaluation-n-methylpyrrolidone-nmp#documents.
[11] Systematic Review Supplemental File: Data Quality Evaluation of Environmental Release and Occupational Exposure Data, pp. 61, 454-455, 462-463, 489-490, 669-674, and 691, https://www.epa.gov/sites/production/files/2020-12/documents/5._nmp_sr_supplemental_file_data_quality_evaluation_of_environmental_release_and_occupational_exposure_data.pdf.
[12] Risk represents the intersection of hazard and exposure. Where there is no exposure, there is no risk. Because there is no exposure to NMP in our manufacturing processes, the use of quotation marks around "risks" is appropriate.

already uses. As Dr. Freedhoff recently said, “I am also committed to sensible consideration of all the things that companies do to protect their workers in the risk management phase. . . . No one at EPA wants to invent some new unnecessary requirement when existing practices do the job.” The Coalition supports such an approach for the use of NMP in lithium ion cell manufacturing.

As illustrated above and further explained in our previous submissions, the current industry practices for lithium ion cell manufacturing prevents any actual exposure of NMP to workers and therefore is sufficiently protective. The information that our Coalition has provided to EPA should guide the Agency as it develops TSCA Section 6 rules that affect our industry. For example, EPA could codify the requisite gloves that we use for each manufacturing activity. EPA could also set duration requirements for the hypothetical situation when there is immersion of workers’ hands with NMP—even though this scenario does not actually occur in our facilities. Again, we must reiterate that the necessity for absolute product purity demands no immersion with NMP. Establishing glove requirements and duration restrictions on dermal immersion alone would sufficiently protect workers against the perceived risks identified in the final risk evaluation.

In the Alternative, EPA Must Grant a Critical Use Exemption

If, for whatever reason, EPA is reluctant to implement our industry standards as the regulatory standards, the Agency must grant an exemption under TSCA Section 6(g) for lithium ion cell manufacturing. Domestic manufacturing of lithium ion cells and batteries is crucial to fulfill the Biden-Harris Administration’s goals of electrifying the vehicle fleet and transitioning our power supply to renewable energy. Without domestic manufacturing of our cells and batteries, these ambitious aspirations will remain unfulfilled and unrealized.

Under TSCA Section 6(g)(1), EPA may grant an exemption from a requirement under a TSCA Section 6(a) rule for a specific condition of use, such as lithium ion cell manufacturing, if the Administrator finds that:

(A) The specific condition of use is a critical or essential use for which no technically and economically feasible safer alternative is available, taking into consideration hazard and exposure;

(B) Compliance with the requirement, as applied with respect to the specific condition of use, would significantly disrupt the national economy, national security, or critical infrastructure; or

(C) The specific condition of use of the chemical substance, as compared to reasonably available alternatives, provides a substantial benefit to health, the environment, or public safety.

For the reasons set forth below, lithium ion cell manufacturing requires a Section 6(g)(1) exemption if EPA does not adopt the industry standards as the regulatory standards. Failure to do so would not only be contrary to law and fact, but any excessive restriction or prohibition on our ability to continue to use NMP in our manufacturing processes would also jeopardize the domestic manufacturing of lithium ion cells and batteries. Each of the mutually exclusive exemptions under TSCA Section 6(g)(1) applies to our use of NMP.

First, as previously noted in this letter and our prior submissions to EPA, the use of NMP is critical to the manufacture of lithium ion cells. Without it, we simply cannot produce our cells. There is no known or proven alternative chemical substance that can be used in our manufacturing processes. Given that there is no actual exposure to NMP in our processes, EPA should have no concerns with granting an exemption under Section 6(g)(1)(A).

Second, fully supporting an exemption under Section 6(g)(1)(B), the White House's June 2021 report on supply chains and U.S. manufacturing emphasized that domestic lithium ion cell technology and manufacturing capabilities are critical to the national and economic security of the United States.[13] Indeed, the report stated that "[m]aintaining America's innovative and manufacturing edge in the automotive sector and other key industrial sectors will require the United States to undertake a concerted effort to shore-up sustainable critical material supply and processing capacity, expand domestic battery production, and support EV and storage adoption."[14] The report also recommended financing for facilities that manufacture advanced technology vehicle battery cells and packs in the United States.[15] The report observed that "the opportunity for the United States to secure a leading position in the global battery market is still within reach if the Federal Government takes swift and coordinated action."[16] Finally, the report recommended that the government promote sustainable domestic battery materials, cell, and pack production.

The White House will not achieve any of these goals if NMP is unduly restricted or prohibited in the manufacture of lithium ion cells. As we have previously noted, NMP is a critical chemical for our manufacturing processes. No alternative exists to replace NMP for our use. Therefore, without following the path(s) recommended in this letter, EPA may force lithium ion cell manufacturing to move outside the United States—further exacerbating existing critical supply-chain constraints.

Indeed, the explosion in global demand for lithium ion cells and batteries is tied to goods that are critical to the United States—including energy infrastructure, a green vehicle fleet, and advanced medical products, as well as defense systems and military transportation vehicles. Further, the lack of a robust lithium ion cell manufacturing sector in the United States has left U.S. industries vulnerable to global supply constraints. To reverse its growing dependency on imported cells and batteries, and to create a strong and flexible supply chain for high-capacity batteries in the United States, U.S. government agencies must work together to increase support—including regulatory support—for lithium ion cell manufacturing in the United States. This is integral to advancing the United States' position as a viable player in the global lithium ion cell manufacturing sector, which in turn, supports U.S. national security interests. In sum, the Federal Government should be taking steps to promote—not impede—the growth of our rechargeable battery technology in the United States.

Third, lithium ion cells are vital to clean energy technology. The White House's report could not have been clearer: "we cannot afford to be agnostic to where these technologies are

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[13] *Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth*, https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf.
[14] *Id.* at 9.
[15] *Id.* at 13.
[16] *Id.* at 86.

manufactured and where the associated supply chains and inputs originate."[17] Indeed, "[h]igh-capacity batteries—used in electric vehicles (EVs), for stationary storage, and for many defense applications—offer an important and growing market that can support the creation of American jobs, help meet our national security needs, and bring ambitious climate targets within reach."[18] Therefore, in accordance with Section 6(g)(1)(C), lithium ion cell manufacturers' use of NMP, as compared to the alternative of no cell production (given that there are no reasonably available alternatives), provides a substantial benefit to health, the environment, and public safety.

We would welcome the opportunity to meet with EPA staff in the coming months, as the Agency develops the proposed risk management regulations for NMP, to discuss our proposed path forward and to answer any questions that you and your staff may have. As always, we appreciate the Agency's continued engagement on this critical issue.

Respectfully Submitted,

Erik Baptist

Erik C. Baptist

Attachments

cc:

Dr. Michal Ilana Freedhoff
Assistant Administrator
Office of Chemical Safety and Pollution Prevention

Mr. Mark Hartman
Deputy Director
Office of Pollution Prevention and Toxics

Ms. Eileen Sheehan
Senior Policy Analyst
Office of Pollution Prevention and Toxics

Ms. Clara Hull
Environmental Protection Specialist
Office of Pollution Prevention and Toxics

[17] *Id.* at 8.
[18] *Id.* at 85.

ATTACHMENT A

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January 21, 2020

Hon. Andrew Wheeler
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Ave. NW
Washington, DC 20460–0001

Re: Docket No. EPA-HQ-OPPT-2019-0236, Toxic Substances Control Act (TSCA) Draft Risk Evaluation for n-Methylpyrrolidone (NMP)

Dear Administrator Wheeler:

The Lithium Ion Cell Manufacturers' Coalition (Coalition) appreciates this opportunity to provide comments, through its counsel Wiley Rein LLP, to the U.S. Environmental Protection Agency (EPA) concerning the draft TSCA risk evaluation for NMP (Chemical Abstract Services Registry Number (CASRN) 872-50-4) noticed in the Federal Register on November 7, 2019. 84 Fed. Reg. 60087. At the request of this Coalition and others, EPA subsequently extended the comment period from January 6, 2020 to January 21, 2020. 85 Fed. Reg. 310 (Jan. 3, 2020).

Our members represent lithium ion cell[1] manufacturers and their downstream users. Lithium ion cells are used in many products that rely on rechargeable battery technology, such as electric cars, energy storage, medical devices, portable electronics, defense manufacturers, and the aerospace industry. Many of these cells are produced in facilities located across the United States, creating thousands of good-paying jobs and sustaining their surrounding communities. We would like to thank EPA for extending the comment period and respectfully ask the agency to revisit its preliminary risk finding on workplace exposure to NMP during the manufacture of lithium ion cells based on the new information presented in these comments.

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[1] Even though EPA's draft risk evaluation used the word "battery," for the sake of accuracy, the Coalition's comments will use the technical term "cell" to describe the technology used in rechargeable batteries (which are comprised of one or more cells). Oftentimes, cells are manufactured in different facilities than batteries. The Coalition understands that EPA's draft risk evaluation intended to cover the manufacturing of lithium ion cells. Indeed, NMP is used in the cell manufacturing, not the battery assembly, process.

I. Executive Summary

EPA selected NMP as one of the first 10 chemicals for risk evaluation under section 6 of TSCA. EPA is under a statutory deadline to complete the NMP risk evaluation by no later than June 2020. The agency must determine whether NMP "presents an unreasonable risk of injury to health or the environment, without consideration of costs or other non-risk factors, including an unreasonable risk to a potentially exposed or susceptible subpopulation identified as relevant to the risk evaluation by the Administrator, under the conditions of use." With over 50 conditions of use under review, the draft risk evaluation for NMP showcases the comprehensive nature of the agency's assessment of the potential hazards and exposures from a wide range of uses for NMP.

EPA has collectively evaluated the manufacturing of lithium ion cells together with several other uses of NMP in electrical equipment, appliance, and component manufacturing that include the cleaning of electronic parts, the coating of electronic parts including magnet wire coatings, and photoresist and solder mask stripping. In so doing, EPA has assumed that engineering and workplace controls, job descriptions, and uses of NMP are substantially similar in all types of manufacturing in this category. That is incorrect. In making this distinction, we do not suggest that these other manufacturing processes inadequately protect their workers. Instead, we submit that when EPA receives information specific to a particular manufacturing process, which may distinguish it from other processes, the agency must consider that particular manufacturing process as a separate condition of use.

These comments are designed to better inform EPA's evaluation of the conditions of use associated with NMP during lithium ion cell manufacturing. EPA has already found that lithium ion cell manufacturing meets the TSCA safety standard of no unreasonable risk with respect to the general population, the environment, and consumers. We agree. In addition, we are providing information on the robust engineering and occupational controls that are implemented by the lithium ion cell manufacturing industry to prevent worker exposure to NMP. We thus ask EPA to use our information to conduct a stand-alone evaluation of these operations. The information presented by these comments supports a finding that there is no unreasonable risk to workers under the conditions of use for lithium ion cell manufacturing.

In the manufacturing of lithium ion cells, NMP is used only as a carrier for the binder resin used to form the cathode (and to a lesser extent, the anode) component of the cell. The importance of purity and low moisture for lithium ion cathode and anode production compared to typical parts-washing applications is evident from the sales specifications for typical parts washing grade NMP compared with the micropure NMP used to make lithium ion cells. As a result, lithium ion cells are produced in a tightly controlled manufacturing environment and closed pipe systems are used for NMP transfer. The engineering controls and personal protective equipment (PPE) our industry employs are expressly designed to *prevent* worker exposure to NMP. For example, our companies comply with the Occupational Safety and Health Administration's (OSHA's) worker

protection standard (29 C.F.R. § 1910.132(d)), which requires the use of PPE wherever necessary. Moreover, where NMP recovery systems are employed in lithium ion cell manufacturing, shipments and handling of virgin NMP and waste material are reduced compared to other operations in the electronics category. EPA must take these factors into consideration as part of the conditions of use for NMP by our industry.

Lithium ion cell manufacturing is a distinct condition of use and many exposure assumptions that EPA used in the draft risk evaluation for the electronic parts category are not representative of our industry. For example, EPA's assumptions of direct, prolonged hand contact with liquid NMP for half or full shift periods are inappropriate in relation to our workers. EPA must consider our enclosed systems, limited direct handling of NMP, and use of full coverage PPE, including fully protective gloves. EPA simply cannot characterize risk for our operations based on the assumption that no dermal hand protection is provided to our workers. This is never the case in our industry.

In addition, the Coalition is concerned with EPA's handling of reliable air sampling data that present observations falling below detection limits. Most of the data submitted for the electronic parts category (96%) reflected readings that were below a detection limit equivalent to California's occupational exposure limit for NMP. And yet, EPA found unreasonable risks to workers. That preliminary determination appears to result from several built-in conservatisms in the draft risk evaluation. While we believe these monitoring data to be generally representative of our industry, we think that EPA's overly conservative use of these data discourages more affected industries from gathering reliable data and undermines EPA's stated commitment to apply a weight-of-the-evidence approach. Better science-based approaches are available for employing the use of these monitoring data to evaluate exposure, as described in Part VII below, that EPA should be using instead.

The limited availability of the PBPK model that EPA used creates a lack of transparency and reproducibility regarding how worker blood concentrations were estimated. EPA needs to either make this model available, along with the inputs that the agency used, or rely on a publicly available model for its risk evaluation. Otherwise, stakeholders are not afforded a fair opportunity to assess EPA's underlying analysis or the ability to provide fully informed comments on the agency's modeling approach.

Finally, EPA should revise its analysis of our workplaces to account for the actual use of enclosed pipe systems and head-to-toe PPE, including NMP-resistant butyl rubber gloves. Based on the statutory requirements to use best available science and reasonably available information in these TSCA risk evaluations, we ask EPA to revisit and improve the risk evaluation. Risk is defined as the likelihood of harm based on both the hazard and the exposure. These comments explain in detail the extensive engineering controls and effective PPE our industry uses to prevent worker exposure to NMP. The lack of exposure to NMP in lithium ion cell manufacturing as discussed in these comments demonstrates that NMP does not present an unreasonable risk to workers in our industry.

II. The Lithium Ion Cell Manufacturers' Coalition

The Coalition is comprised of entities that manufacture and rely on lithium ion cell technology, and the trade associations that support these industries. In alphabetical order, they are the following entities: The Alliance for Automotive Innovation, Enersys, Integer, Panasonic, PRBA – The Rechargeable Battery Association, and Saft America.

Formed by the merger of the Association of Global Automakers and the Alliance of Automobile Manufacturers, the Alliance for Automotive Innovation (the "Auto Innovators") is dedicated to helping that innovation come to market safely and cleanly. Propelled by the collective energy of the world's multi-faceted auto industry, the Auto Innovators represent innovative manufacturers and value chain partners who together produce nearly 99 percent of all light-duty vehicles sold in the United States. The Auto Innovators work to speed the safe deployment of advances in personal transportation through effective public policy, stakeholder engagement and greater public understanding.

Headquartered in Reading, Pennsylvania, EnerSys manufactures and distributes reserve power and motive power batteries, battery management systems, battery chargers, power equipment, battery accessories and outdoor equipment enclosure solutions to customers worldwide. With $2.8 billion of sales in 2019, EnerSys employs more than 11,000 workers worldwide and has over 10,000 customers in more than 100 countries.

Integer Holdings Corp. ("Integer") is one of the largest medical device outsource manufacturers in the world serving the cardiac, neuromodulations, vascular, and portable medical markets. For over 70 years, Integer has provided innovative, high-quality technologies and manufacturing to medical device manufacturers to enhance the lives of patients worldwide. In addition, Integer develops batteries for high-end niche applications in energy, military, and environmental markets. Greatbatch Medical, Lake Region Medical, and Electrochem comprise the company's brands.

Headquartered in Sparks, Nevada, Panasonic Energy of North America, a Division of Panasonic Corporation of North America ("Panasonic"), is the premier manufacturer of powerful, energy-efficient long-lasting batteries. Panasonic is invested in finding solutions for sustainable global development. Panasonic is the largest manufacturer of primary cylindrical lithium ion cells in North America. Using stringent controls and advanced production techniques, Panasonic produces batteries to the highest quality and performance standards.

PRBA – The Rechargeable Battery Association ("PRBA") serves as the voice of the Rechargeable Power Industry, representing its members on legislative, regulatory, and standards issues at the state, federal, and international level. PRBA works on a broad range of issues impacting manufacturers and users of large format lithium ion batteries and nickel metal hydride batteries.

For 50 years, Saft America ("Saft") has been specializing in advanced-technology battery solutions for industry – in space, at sea, in the air, and on land. With five locations across the United States, Saft produces a range of battery chemistries for a variety of customers, including the military and energy companies. Saft also manufactures batteries for the aerospace, medical, telecommunication, and transportation industries.

III. Need for Stand-alone Evaluation for Lithium Ion Battery Manufacturing

EPA should use the information supplied in these comments to conduct an independent evaluation of our operations, separate from the category of other electronic parts manufacturing. EPA should do so because of a number of differences in the process and engineering controls at our sites, compared with other sites in the category of electronics manufacturing that perform cleaning and coating activities using NMP-based products.

The lithium ion cell has the highest energy density of any rechargeable cell. It is a major driving force in the expansion of all manners of commercial, personal, and portable electronic devices. Lithium ion cells are used in high performance applications throughout the United States and the world for industrial infrastructure, transportation, communications, medical devices, aerospace, defense, clean vehicles, and renewable energy storage, including large-scale, stationary lithium ion battery grid energy storage. In the draft risk evaluation, EPA acknowledges that the use of NMP in lithium ion cell manufacturing is expected to continue to expand. (Draft Risk Evaluation pp. 17, 29). No alternatives have been proven on a commercial scale. Further discussion concerning current and future developments in U.S. battery production is provided by Lowe *et al.* (2010).

As recognized by the draft risk evaluation, NMP is not a final component in lithium ion cells. On p. 78 of the Draft Risk Evaluation for N-Methylpyrrolidone (2-Pyrrolidinone, 1 Methyl) (NMP) Supplemental Information on Occupational Exposure Assessment (Oct. 2019), EPA states that NMP is used as a solvent in lithium battery manufacturing, citing Mitsubishi Chemical, 2017. That information is correct. NMP does not remain in or on the lithium ion cell, however, after the manufacturing process. In the very same paragraph, EPA states, and we quote, "Specifically, NMP is used as a carrier for binder resins used to adhere electrolytic cells to the battery", citing Roberts, 2017, Argonne National Laboratory, 2015, and RIVM, 2013. This is not the case. NMP is not used this far downstream in our processes. NMP would not be used to adhere finished cells to prevent vibration. NMP is used earlier in the process primarily to adhere the cathode powder to the aluminum foil. As noted in a public comment submitted to the EPA NMP risk evaluation docket, NMP is mixed with powder chemicals and binders, and then the solution is coated onto thin metal foils with a precise automated roll coating process (Roberts, 2017). Figure 1 illustrates the components of a lithium ion cell.

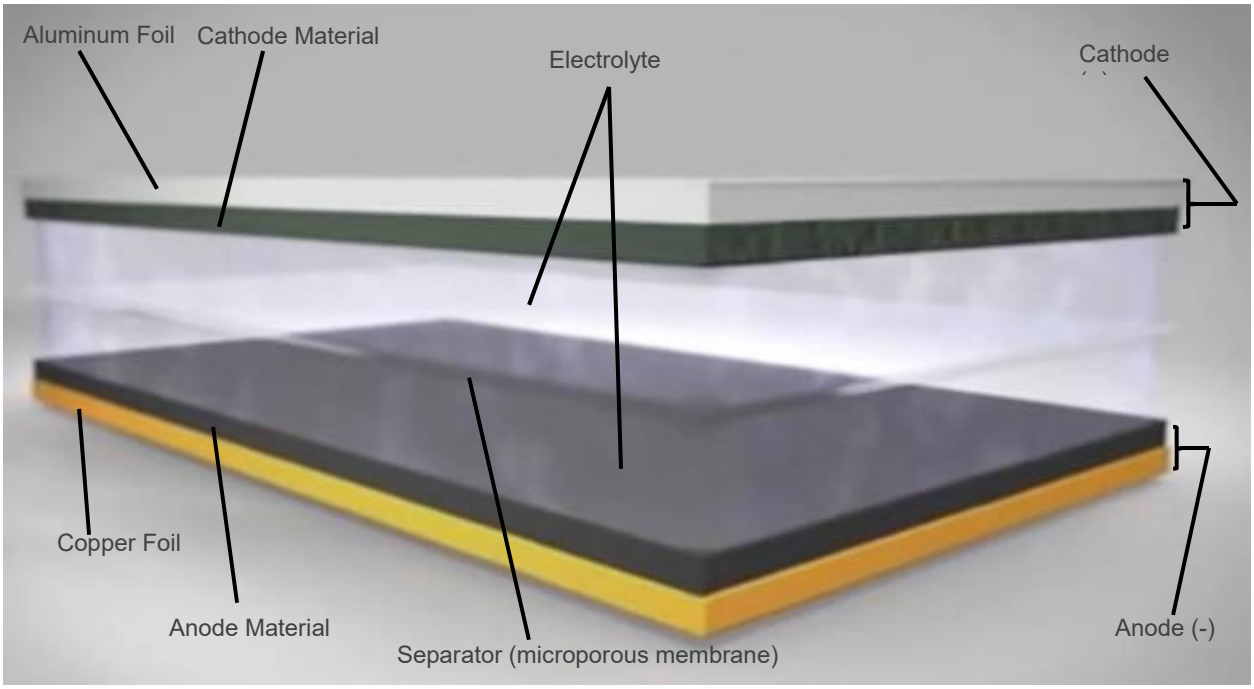

Figure 1. This diagram of the primary components of a lithium ion cell is for illustration purposes only. Source *https://www.youtube.com/watch?v=2PjyJhe7Q1g*

The components illustrated above can be briefly explained as follows:

Aluminum Foil: The conductive surface on which the cathode material is deposited.

Cathode Material: A mixture of a positive active material, a conductive diluent, and a binder. The mixture serves as the active positive electrode when applied to the aluminum foil substrate.

Cathode (+): The aluminum foil and cathode material are collectively referred to as the Cathode, which is the positive electrode component of the cell.

Copper Foil: The conductive surface on which the anode material is deposited.

Anode Material: The anode material is a mix of negative active material, a conductive diluent, and a binder. The mixture serves as the active negative electrode when applied to the copper substrate.

Anode (-): The copper foil and anode material are collectively referred to as the Anode, which is the negative electrode component of the cell.

Electrolyte: A proprietary liquid organic solvent mixture that allows the flow of electrical charge between the cathode and the anode.

Separator: Microporous membrane that allows the passage of lithium ions during cell charging and discharge.

Even though NMP is not found in completed lithium ion cells and is seldom mentioned in academic literature regarding lithium ion cell design or materials development, it plays a critical role in the cell making process, by allowing production of high energy density cathode materials. Lithium ion cathodes are composed of lithium-metal-oxide powders, such as LiCoO2 (cobalt oxide chemistries), LiMn2O4 (manganese oxide chemistries), LiNixCoyAlzO2 (NCA chemistries), or LiNixMnyCozO2 (NMC chemistries), mixed with conductive agents (carbon) and a binder (polyvinylenedifluoride or PVdf) coated onto an aluminum foil current collector. Discussion of these materials, examples of electrode structures, and descriptions of lithium ion cell overall construction as shown above in Figure 1 can be found in a number of references. As coating technology is critical to producing high performance lithium ion cells, however, that technology is generally considered highly proprietary. Diagrams provided in Figures 2 and 3 are sourced from among the few references that discuss the actual process of producing cathode.

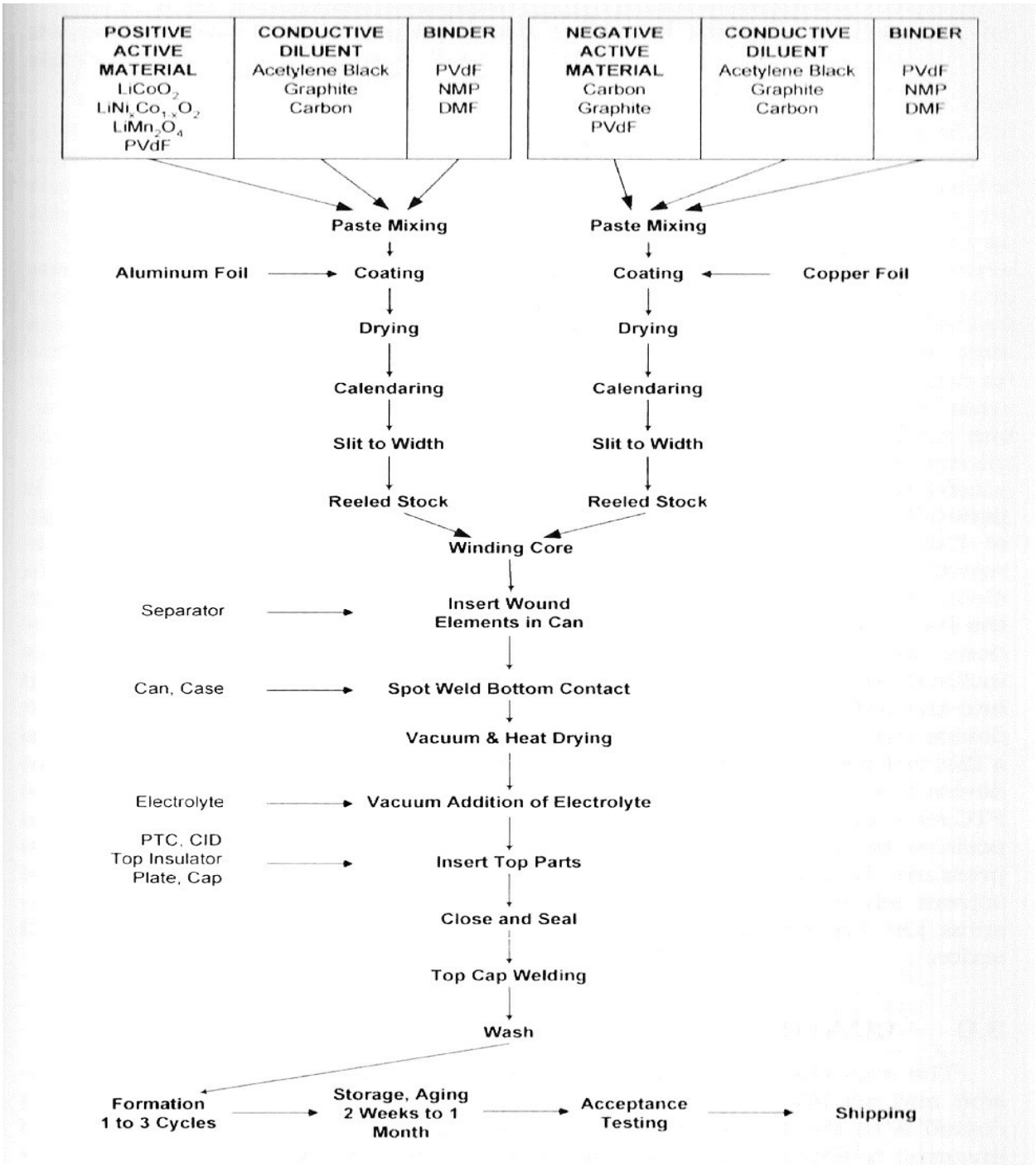

Figure 2: Outline of Lithium Ion Cell Production, from Advances in Lithium-Ion Batteries. Note that not all materials are used in every manufacturing process (DMF is abbreviation for Dimethylformamide). Source: Brodd, R.J. and Tagawa, K. 2002.

To produce a lithium ion cell *cathode*, the manufacture must mix the relevant oxide powder, conductive agent, and binder, and then suspend and dissolve that mixture in a

liquid to make a slurry. The slurry is pumped to a coating die-head and deposited onto a foil current collector. The wet coated foil is passed through a drying oven to drive off the liquid. The resulting coated foil is then slit to the appropriate shape for cell making. The manufacturer will attempt to maintain strict controls on coating thickness, density, particle distribution, composition, impurity levels, and other properties.

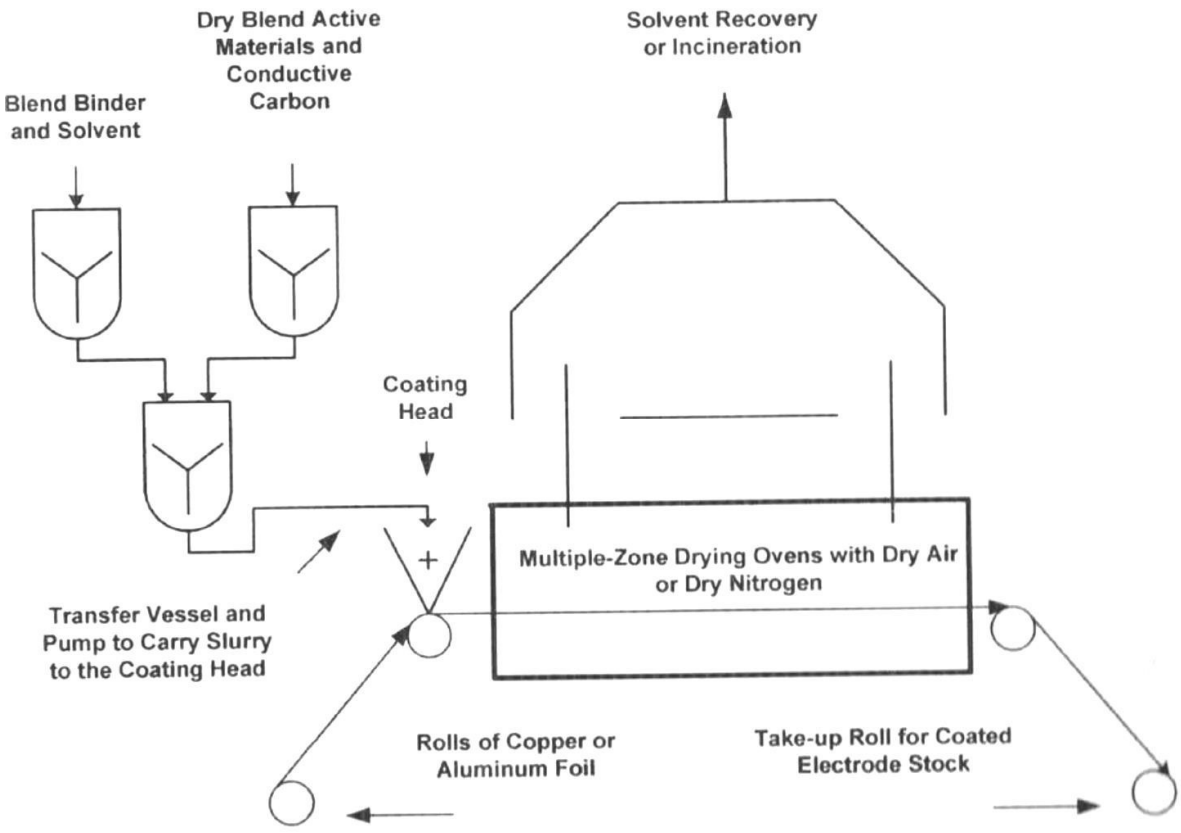

Figure 3: Outline of Lithium Ion Cathode Production Process, from Advances in Lithium-Ion Batteries. Source: Brodd, R.J. and Tagawa, K. 2002.

The liquid used to create a slurry that can be coated must be sufficiently dense and have sufficient viscosity to allow stable suspension of the solids as it is pumped from the mixer to various storage tanks and then to the coating die-head. Low volatility at room temperature is required to ensure a stable slurry composition and to prevent the formation of gas bubbles that can cause voids in the coated product. The liquid must also be readily evaporated in drying ovens, however, so it must have high volatility at moderately elevated temperatures. Ideally, the liquid will readily dissolve binder agents and disperse them evenly around the oxide particles so that the resulting coating is well-adhered to the current collector. Beyond the technical requirements for cell making, liquids used to

produce slurries are evaluated based on their ease of handling, toxicity, and cost. The functional role of the binder resin is to hold the active material particles together for the cathode and anode, respectively. There is no substitute. Lithium ion cathode cells cannot be manufactured without NMP. Therefore, NMP remains the liquid of necessity for producing state-of-the-art high energy density cathodes.

In particular, NMP must be used to produce those cathode chemistries containing nickel oxides (NCA and NMC chemistries), because these oxide materials are not stable when exposed to water. Water causes irreversible changes to particle surface structure that impedes the transfer of lithium ions resulting in reduced capacity and high internal impedance. As nickel content increases in cathode materials, the sensitivity to moisture increases. Cell development roadmaps across the industry involve higher nickel content cathode materials, with nickel oxide almost entirely replacing cobalt oxide in proposed designs. To produce anode (typically graphite) slurries, water is typically used in modern lithium ion cell production. NMP can also be used in the anode production; the process and controls are very similar to the cathode process.

NMP can be purified (distilled) to a very low moisture and impurity content, but it must be maintained in very dry and clean conditions to prevent absorption of water, and to maintain its purity. Dry room design for lithium ion cell assembly is highly specialized and includes the selection of supporting dehumidification equipment, controls, and air distribution systems for moisture control. Moisture must be avoided and controlled because it would cause the electrolyte to oxidize and degrade nickel. Consistent and precise humidity/dew point environmental conditions are required to assure a high-quality manufacturing process.

The importance of purity and low moisture for lithium ion cathode production compared to typical parts-washing applications distinguishes typical parts washing grade NMP with the micropure NMP used in lithium ion cell making. NMP used for lithium ion cell making has substantially lower moisture content, and it must be tested for 28 possible contaminants versus only one for parts-washing grade material. Thus, in all cases, lithium ion cell manufacturers strive to control every material in the NMP pathway, including the metals and other materials used in piping, valves, and mixing and coating equipment. Any contact with workers and their PPE is avoided whenever possible. All NMP tanks with the exception of the slurry tanks, are equipped with a nitrogen blanketing system as a measure to protect the quality of the NMP.

Because of purity concerns alone, *nowhere* in a commercial lithium ion cell manufacturing process are workers expected to immerse their hands in NMP or NMP-based slurries – *with or without proper PPE*. Non-routine operations such as maintenance activities or recovery from process upsets require the use of PPE because, in the absence of PPE, they could put workers in contact with NMP outside of established engineering controls.

All lithium ion cells are assembled in generally the same manner. To achieve high-required cell performance, meet quality requirements, and maintain safety, our facilities

are tightly controlled to include the use of dry rooms and contained systems for the on-site generation, processing, and reuse of NMP. These tightly controlled process requirements for assembling lithium ion cells illustrate the ways in which our use of NMP is unique from other industries in the electronics category and why our operations should be evaluated separately.

IV. Engineering and Workplace Controls That Prevent Exposure to NMP

The requirements set forth by OSHA, specifically OSHA's worker protection standard, require employers to provide and have affected employees use PPE wherever it is necessary by reason of hazards present in the workplace. For example, 29 C.F.R. § 1910.132(d) requires employers to "assess the workplace to determine if hazards are present, or are likely to be present, which necessitate the use of personal protective equipment (PPE). If such hazards are present, or likely to be present, the employer shall . . . [s]elect, and have each affected employee use, the types of PPE that will protect the affected employee from the hazards identified in the hazard assessment."

As documented in the December 2019 "TSCA New Chemical Determinations: A Working Approach for Making Determinations under TSCA Section 5," EPA generally expects the submitter and any future manufacturers and processors to comply with federal and state laws to protect workers, including OSHA's worker protection standards. Additionally, because EPA requires that the original submitter's Safety Data Sheet (SDS) reflect Agency recommendations to protect workers from risks identified in EPA's assessment, including PPE and hazard communication, future users of the chemical will have this information available to them when determining how to comply with OSHA's worker protection standards. Therefore, unless case-specific facts indicate otherwise, EPA believes that a chemical is generally not likely to present unreasonable risks to workers if the use of PPE and/or other exposure controls would mitigate potential risk.

Similarly, in EPA's proposed "Regulation of Persistent, Bioaccumulative, and Toxic Chemicals Under TSCA Section 6(h)," the agency stated that it "expects there is compliance with federal and state laws, such as worker protection standards, unless case-specific facts indicate otherwise, and therefore existing OSHA regulations for worker protection and hazard communication will prevent occupational exposures that are capable of causing injury from occurring. 84 Fed. Reg. 36728, 36745 (July 29, 2019). Therefore, "EPA expects that employers will require, and workers will use, appropriate PPE consistent with 29 CFR 1910.132, taking into account employer-based assessments, in a manner sufficient to prevent occupational exposures that are capable of causing injury." *Id.* Because EPA was "not aware of any exposures to *unprotected* workers, based on information gather by EPA," the agency concluded that "additional workplace regulations that EPA could impose are unlikely to result in meaningful exposure reductions." *Id.* (emphasis added).

EPA should apply this same approach consistently for existing chemical evaluations under section 6(b). As with the new chemicals program, where companies have identified

controls to protect workers, EPA must consider those controls rather than the absence of them when evaluating conditions of use. More specifically, EPA's assessment must include consideration of engineering controls described. If risks are preliminarily identified, EPA then must consider whether the risk is mitigated by the use of PPE, and if so, no finding of unreasonable risk is warranted.

We ask EPA to rely on the following information, which establishes that (1) our workers have minimal opportunities for direct exposure to NMP and (2) that engineering controls and PPE reduce exposures to levels that present no unreasonable risks to human health. Compared with other industries in the electronic parts category, the handling of NMP in small containers in cell manufacturing facilities is limited to infrequent use in the laboratory or small-scale operations where they are opened only in ventilated hood areas with personnel equipped with extensive PPE (*e.g.*, Figure 8) for no more than 30 minutes a shift (even in these operations, mixing and further processing takes place in fully enclosed systems). NMP is not typically handled in drums, even by smaller cell manufacturers, due to process quantity demands. NMP is delivered to most lithium ion cell manufacturing facilities by rail car and/or semi-trailer truck. Once onsite, NMP is contained in storage tanks. All tanks are clearly labeled and include secondary containment (Figure 4).

Figure 4: NMP storage tank in mixing area.

In all cases, ultra-pure NMP is pumped through closed piping to storage tanks in the cathode mixing area. Mechanical pumps are used to convey the NMP through the processing equipment. In this way, NMP used for cathode production comes from a closed system. When needed for mixing, NMP is pumped from storage tanks to closed mixing pots in closed piping. These pots remain closed throughout the mixing process, material addition is accomplished through process piping. Tanks are designed with secondary containment. (Figure 5).

Figure 5: Cathode mixing pot.

Mixing of dry material with NMP is conducted under nitrogen in closed mixing pots that are designed to prevent moisture ingress, as well as loss of cathode powders. These systems are fully automated. Workers initiate a pre-set mixing program in a closed vessel. At no time are workers manually spraying or mixing NMP or NMP-containing slurry. Once mixing is complete, mixing pots remain closed while the resulting slurry is pumped in closed piping to slurry storage tanks and then to coating die-heads (Figures 6 and 7).

Figure 6: Slurry storage tank

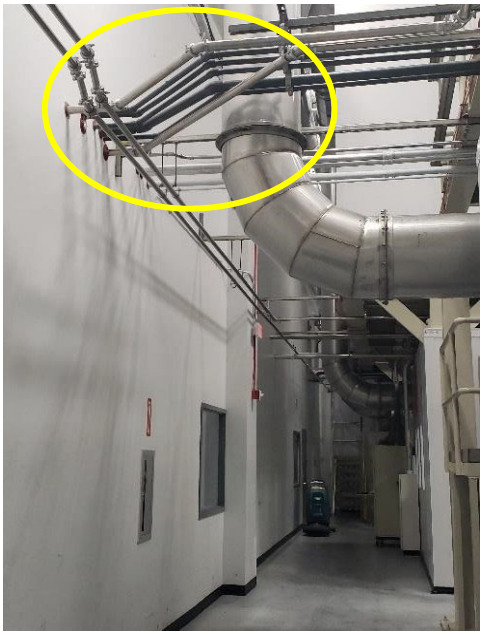

Figure 7: Slurry piping between mixing area and coating equipment (circled)

Moreover, the coating process is automated. Operators monitor and adjust a die-head that applies slurry to aluminum foil. Coating is applied with a slot die; it is not sprayed onto the current collector. The wet coated material immediately enters a drying oven. Because coating uniformity is critical, operators are never to touch a wet coating surface or the face of the die-head.

Finally, access to cathode mixing, coating, and drying areas where NMP is used is tightly controlled in the following respects:

- Personnel working in mixing and coating areas receive *extensive training* regarding the processes and proper PPE. Standard Operating Procedures (SOPs) are utilized for routine and non-routine tasks and specify training and required PPE. We specifically ask EPA to take extensive training in our industry into account, as the lack of information in this area was noted in the draft risk evaluation as a basis for not assuming a generic protection factor (PF) of 20 for protective glove use (p. 69). We think the information that we and others are submitting supports the conclusion that our use of butyl gloves meets the PF 20 protection;

- Badge access is required to enter facilities and secured areas;

- Personnel entering these areas for routine work must undergo a gowning procedure for quality and safety purposes that includes donning in-process safety shoes, Tyvek suits, nitrile gloves, safety glasses, hairnet, and mask. These PPE

are not intended for operations involving intentional contact with NMP or NMP-based slurries;

- Additional PPE is provided for work that will involve contact or potential contact with NMP and includes chemical resistant suits, respirators, and chemical resistant gloves, depending on the task performed. These workers are required to wear full-body chemical resistant suit with booties/shoe covers. The equipment includes a PAPR and hood with organic/acid gas + HEPA cartridge coverage. Gloves are required, typically double latex for limited contact with NMP. Butyl gloves are required when contact with NMP is expected. This PPE is shown in Figure 8;

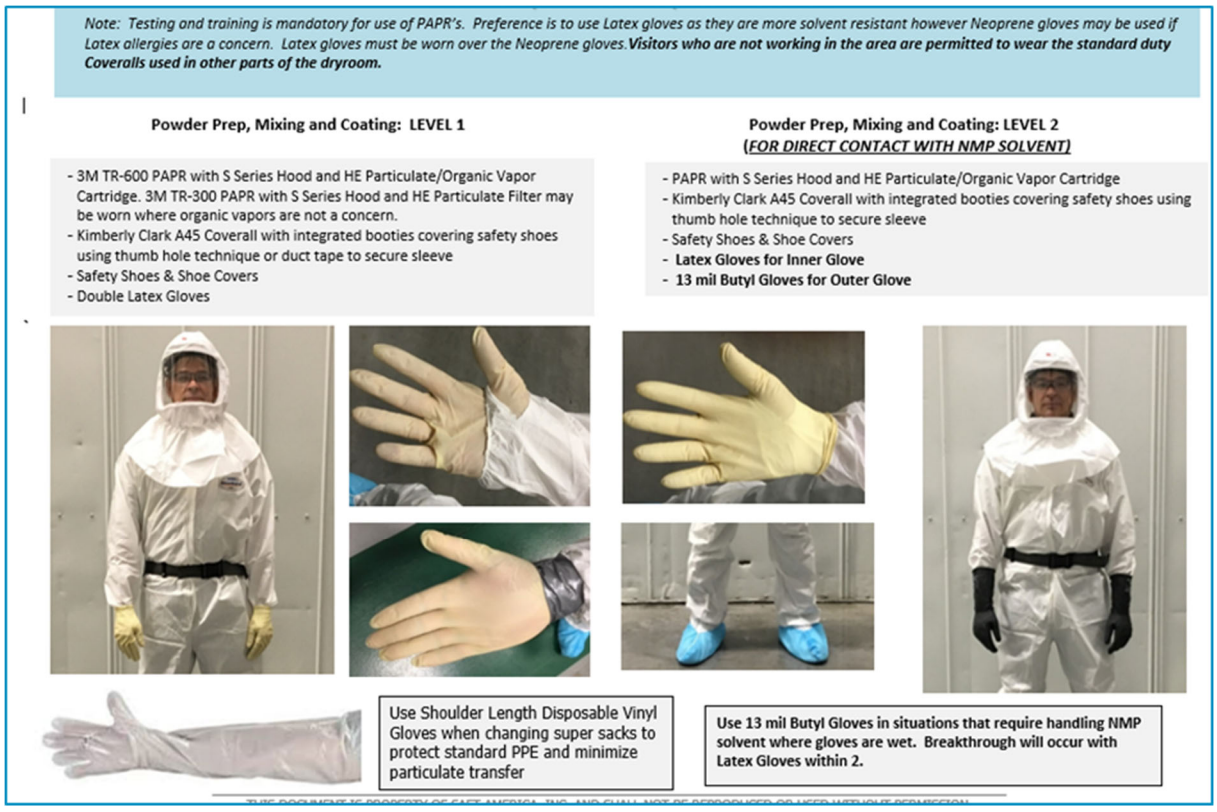

Figure 8. Required PPE for workers handling NMP in the manufacture of lithium ion cells.

- The PPE required during off-loading of NMP is shown in Figure 9. It includes an NMP resistant chemical suit, NMP resistant butyl gloves, NMP resistant butyl boots, a face shield, and tight-fitting chemical splash goggles;

Figure 9. PPE for Offloading.

- For the purposes of ensuring worker health and safety, exposure risk assessments are conducted to verify the efficacy of engineering and administrative controls; and

- Safety showers and eyewash stations are installed in areas where NMP is used.

For the record, EPA has issued several consent orders and associated significant new use rules (SNURs) for the use of cathode powders that already require the extensive use of PPE in cathode mixing operations during lithium ion cell manufacturing, such as 40 C.F.R. § 721.11027. Therefore, EPA-imposed PPE is already required and should be taken into consideration in this risk evaluation.

In summary, the Coalition believes that EPA's draft finding of unreasonable risk for workers during lithium ion cell manufacturing is based on erroneous assumptions concerning how our industry handles NMP, implements engineering controls, and protects workers. In practice, the structure and operations of cell manufacturing facilities are designed to largely eliminate opportunities for any human contact with NMP. Workers have minimal opportunities for direct exposure to NMP, as engineering controls and PPE reduce exposures, if any, to levels that present no unreasonable risks to human health.

V. NMP Recovery

After coating is complete, lithium ion cell manufacturers capture vapor driven off by the electrode drying process, condense the vapor, and either recover or dispose of the liquid. It is indispensable for the solvent to be vaporized and completely removed from the electrodes after coating. Therefore, during the drying process, the NMP solvent is volatilized and the "oven air" can be captured and conveyed to an NMP recovery system, with up to approximately 12% immediately returned to the coating/drying system. During this process, it is important to remember that emissions are greatly limited and any would-be exposures to workers are prevented through the use of PPE.

Because NMP is costly and the production of lithium and other hybrid cells needs large amounts of NMP, the recovery and reuse of NMP can be a vital part of the lithium ion cell manufacturing process. Most manufacturers will recover condensed NMP and either re-distill this material on-site or the condensed NMP liquid is taken by licensed haulers for off-site recycling. On-site distillation involves sending NMP-laden exhaust through de-ionized water where the highly soluble NMP (miscible in water) absorbs into the water. The NMP-laden water is transferred to a tank located inside the building and then to the outdoor storage tanks pending processing in the NMP refining system. The NMP refining system consists of two distillation columns. In the first column, the water, which has a boiling point lower than that of NMP, is distilled from the mixture and sent to the onsite wastewater treatment plant. The NMP, which is now free of water, is transferred to the second distillation column where reusable NMP is distilled from degraded NMP (waste stream). Degraded NMP is stored in an outdoor tank pending off-site disposal and the reusable NMP is transferred back into the large outdoor NMP tanks for reuse. Ideally, to maintain purity, reusable NMP would be pumped directly from a distillation process to the cathode mixing process in a closed system.

The distillation columns are operated under a vacuum, and therefore no NMP emissions have the potential to emanate from the refining column themselves. The exhaust from the vacuum pumps utilized to create the vacuum, however, may contain NMP. The exhaust from these recovery systems must be permitted under the Clean Air Act and consists of water vapor and a relatively low concentration of residual NMP. Water vapor may be collected and discharged to the municipal sewer in compliance with wastewater permit conditions (and may contain approximately 0.9% NMP). Overall as a result of these systems, the vast majority of the NMP is recovered, refined, and reused.

Figure 10: NMP recovery equipment

NMP recovery systems are fully automated, closed systems (Figure 10). Only maintenance workers with prescribed PPE interact with these systems. Maintenance procedures are conducted only on de-pressurized systems. This means for large operations, shipments of virgin NMP are less frequent compared to smaller production facilities and other industries. Where these shipments occur, and in the case of condensed NMP liquid shipments and shipments for disposal of degraded NMP and distillation bottoms, workers are *fully* protected from potential inhalation and dermal exposures through the use of PPE from any contact with NMP (as illustrated by Figure 9). It is not only vital to the manufacturing process, but it is also economical for a lithium ion cell manufacturer to carefully control the purity of the condensed NMP as adding contaminants will increase overall system loss and the cost of recovery. Thus, condensed NMP transport is also designed to prevent contamination.

VI. Other Uses of NMP in the Manufacture of Lithium Ion Cells

The Coalition knows of no other commercial condition of use of NMP in lithium ion cell manufacturing other than as a component of the binder in cathode mixing, and to a lesser extent, in anode mixing. EPA found information that NMP may also be used as an additive in electrolytes and in coatings used on the outside of batteries (RIVM, 2013), but the Coalition is not aware of any lithium ion cell manufacturing for these uses of NMP as noted earlier. In addition to the NMP released to atmosphere from the NMP recovery system, under facility clean air permits, small amounts of fugitive NMP are released from the drying ovens to the coat/dry room air and are exhausted directly to atmosphere.

VII. Comments on EPA's Risk Evaluation Approach[2]

As already noted, in the draft risk evaluation (p. 100), the category of electronic parts manufacturing covers the use of NMP for lithium ion cell manufacturing, cleaning of electronic parts, coating of electronic parts, including magnet wire coatings, and photoresist and solder mask stripping. EPA relied on inhalation monitoring data for the use of NMP in semiconductor manufacturing to characterize worker exposure for the entire category. A comparison of exposure monitoring data that EPA used to assess exposures for the electronic parts manufacturing category with representative, single data points for full-shift personal breathing zone sampling measured by third party insurers at two representative lithium ion cell manufacturing facilities is shown in Figures 11 and 12 below.

Table 2-31. Summary of Parameters for PBPK Modeling of Worker Inhalation Exposure During Electronic Parts Manufacturing

Work Activity [a]	Parameter Characterization	Full-Shift NMP Air Concentration (mg/m^3, 12-hour TWA)	Duration-Based NMP Air Concentration (mg/m^3)	Source	Data Quality Rating
Container handling, small containers	Central tendency (50th percentile)	0.507	No data	(SIA, 2019)	High
	High-end (95th percentile)	0.608	No data		
Container handling, drums	Central tendency (50th percentile)	0.013	No data		
	High-end (95th percentile)	1.54	No data		
Fab worker	Central tendency (50th percentile)	0.138	No data		
	High-end (95th percentile)	0.405	No data		
Maintenance	Central tendency (50th percentile)	0.020	No data		
	High-end (95th percentile)	0.690	No data		
Virgin NMP truck unloading	Single value	4.78 [b]	No data		
Waste truck loading	Single value	0.709 [b]	No data		

[a] Electronic parts manufacturing includes the use of NMP for battery manufacturing, cleaning of electronic parts, coating of electronic parts, including magnet wire coatings, and photoresist and solder mask stripping.
[b] These are 8-hour TWA values.

Figure 11. Electronic manufacturing full-shirt personal breathing zone sampling results from draft NMP risk evaluation.

Battery Manufacturing Facility 1		
Year	**Job Description**	**Exposure Results**
2011	Cathode Mixing	1.2 ppm
2011	Cathode Coating	< 0.11 ppm

[2] We note with appreciation the expertise provided by Integral Consulting, Inc. during the development of the technical sections in these comments evaluating certain methodologies used in the draft risk evaluation.

Battery Manufacturing Facility 1		
2012	R & D	< 0.14 ppm
2012	Mix Room/Large Coater	1.8 ppm
2015	Cathode Mixing	<0.18 ppm
2015	Cathode Coating	0.35 ppm
2017	Cathode Mixing	3.0 ppm
2017	R&D	1.0 ppm
2018	Cathode Mixing	0.43 ppm
2018	R&D	<0.12 ppm
2019	R&D	<0.11 ppm
2019	Maintenance	<0.13 ppm
2019	Fill Room	<0.13 ppm
Battery Manufacturing Facility 2		
2012	Cleaning	1.5 ppm
2012	Cleaning	1.6 ppm
2013	Cathode Mixing	0.85 ppm
2013	Cathode Coating	1.2 ppm
2015	Cathode Mixing	<0.12 ppm
2015	Cathode Mixing	<0.12 ppm
2016	Cathode Mixing	0.65 ppm
2018	Cathode Coating	9.8 ppm
2018	Cathode Coating	5.2 ppm

Figure 12. Representative single data points for full shift personal breathing zone sampling at two representative lithium ion cell manufacturing facilities (8 or 12 hr. TWA).

NMP, as described above, is maintained in enclosed systems in cathode mixing and coating operations. Due to periodic sampling and maintenance operations, NMP is detected in these areas, although the 2018 measurements above considered outlier excursion values that are not normally observed. In addition, workers in these areas are wearing the full protective gear (*e.g.,* Figure 8) to eliminate the potential for inhalation or dermal exposure.

Although exposures appear comparable for our operations, the Coalition has several concerns with how EPA has utilized the data to assess exposure and ultimately risk to workers. Even though the majority (96% of all samples) of the samples in this dataset were non-detect for NMP, EPA has identified an unreasonable risk to workers. This seems to be the result of several – we think too many – built-in conservatisms in the agency's approach.

The primary drivers for EPA's unreasonable risk determination are chronic inhalation and dermal exposure. Occupational exposures were determined through the use of a physiologically based pharmacokinetic (PBPK) model to determine the internal dose based on inhalation and dermal routes of exposure. The Coalition is concerned that the use of this model demonstrates almost complete lack of transparency, because it is not publicly available for use outside of EPA as modified by the agency. EPA has used the acslX code package for PBPK modeling, which the developer sunset in November 2015 and no longer supports. We understand that EPA has made undisclosed modifications to the model, which makes it extremely challenging to replicate and validate the Agency's results. It is also difficult to determine if the best available scientific methods were brought to bear. While EPA made the associated data available late in the public comment process, the results cannot be independently reproduced, nor can more realistic parameters be modeled by those outside the government. In general, we know that the occupational exposure parameters and information needed for the PBPK modeling are the following:

- NMP weight fraction in the liquid product;
- Total skin surface area in contact with the liquid product;
- Glove protection factor (if applicable);
- Duration of dermal contact with the liquid product;
- Air concentration for inhalation and vapor-through-skin exposure; and
- Body weight of the exposed worker.

For the scenarios of dermal exposure to liquid, EPA assumed one-hand central tendency or two-hand (high end) skin surface area exposure. EPA assumed that fresh material is constantly depositing over the time of use such that the concentration on the skin remains essentially constant at the formulation concentration (lines 4766-4768). EPA noted that it had no data regarding the duration of dermal contact with the liquid product, so it arbitrarily assumed exposure duration ranging from 4 to 12 hours. EPA is making these assumptions with and without the use of protective gloves. The effect of these assumptions is to simulate complete immersion of one or both hands (with and without the use of protective gloves) into liquid NMP for hours. No one would dispute that such scenarios are dangerous, but they are not representative of the actual, real-world conditions of use experienced by our workers. There is no opportunity in our industry for this kind of exposure.

EPA should rely on better information and more accurately represent the occupational exposure scenarios experienced by workers including central tendency and high-end scenarios. In our case, the potential worst-case activity pattern is the unintentional and

infrequent splashing onto protective gloves with an assumed PF of 20. In such case, total exposure would be on the order of minutes rather than hours.

In addition, EPA used a single dermal permeability constant in its dermal exposure PBPK modeling (lines 4758-4762). Dermal permeability, however, varies across the body as a result of a number of factors including skin thickness. According to the EPA Exposure Factors Handbook (Chapter 7), mean ± standard deviation thicknesses were 29.3 ± 6.8 um and 173 ± 37.0 um for the back of hand and palm of hand, respectively (p. 7-32). That is, there is a nearly six-fold difference in the thickness of the skin on the palm of the hand than the back of the hand. EPA should use dermal permeability constants in the PBPK model that accurately reflect the variability of skin thickness on the hand.

For the vapor-through-skin route of exposure, EPA assumed that workers wore short-sleeved shirts and long pants. EPA assumed that the head, arms, and hands are entirely exposed unless personal protection equipment (PPE) is worn. Together, the fractional skin area exposed to vapor (SAVC) is 25% of the total skin surface area in the absence of PPE or liquid dermal contact (lines 4774-4781). Information submitted to the docket by the Semiconductor Industry Association shows that the practice in industrial settings, such as electronic part manufacturing, is for complete coverage of head, torso, legs, arms, and hands. Assumptions regarding skin exposure for the vapor-through-skin route of exposure should reflect actual industry practice in the use of personal protective equipment.

In its assessment of dermal exposure to NMP liquid, EPA used generic PF values of 5, 10, and 20 for gloves. Use of these PF values is inappropriate and does not reflect best available science considerations. It ignores available chemical-specific data, which show that the permeation rate of NMP can vary by more than 3 orders of magnitude, depending upon the *material* used in the gloves (nitrile ~ latex > polyethylene > butyl ~ laminate). EPA should utilize chemical-specific data for protection factors of gloves that are likely to be used as PPE in industrial settings with NMP. One study that looked at protective gloves for use with NMP-containing products found that butyl rubber gloves – such as those that are the standard for the lithium ion cell manufacturing industry – were the best choice (Crook and Simpson, 2007).

Only 5 of the 118 personal air samples for the above tasks showed concentrations of NMP above the limits of detection. Three of the five samples (0.01, 0.02, and 0.07 ppm) were for fab maintenance tasks. Two of the five were for waste truck load/virgin NMP truck offload – tasks that occur at many industrial sites and that are not specific to semiconductor manufacturing where LOD ranged between 0.011 ppm and 1.18 ppm. Of the 5 measured samples that did have NMP concentrations above the limit of detection ("LOD"), the highest 8-hr. TWA concentration was 1.18 ppm for tanker truck offloading. Virgin NMP truck offload task, however, is conducted once per year and corrective actions can be identified to reduce potential exposures. The measured exposure in this instance was only 0.18 ppm above the CAL OSHA 1.0 ppm 8-hr. TWA, one-third of the 3.5 ppm ECHA limit, and one-eighth of the AIHA's 10 ppm 8-hr. WEEL. Due to the deficiencies

identified in this section of our comments, we do not think that EPA can maintain that the blood-level results and point-of-departure approach more accurately reflects actual workplace exposures.

The majority of air monitoring results (96% of all samples) were non-detect at the limit of detection of 0.1 ppm. Because the geometric standard deviation of the data set is greater than three, EPA used the LOD divided by two to calculate central tendency and high-end values where samples were non-detect for NMP (U.S. EPA, 1994b). Even the agency acknowledges, however, this method may result in bias due to the high amount of non-detect results. As another example, EPA assumed that typical shifts for all of the industries in this category are 12 hours largely relied on 12-hour TWA values to assess occupational exposure. The agency considered full shift exposures and ignored frequency of exposure information that realistically reflects actual workplace conditions.

EPA has used an arbitrary approach to calculate central tendency and high-end values where samples were non-detect for NMP by dividing the LOD by two. EPA's justification and source document for using this approach is obsolete and out of step with current science. The U.S. Department of Energy has made statistical methods and software for the analysis of occupational exposure data with non-detectable values available (Frome 2005), and EPA has developed and maintained statistical software for analysis of environmental data sets with and without non-detect (ND) observations called ProUCL for a number of years. TSCA risk evaluations should use current science for the treatment of monitoring data with non-detect observations.

VIII. Ramifications for Not Relying on Actual Information on Worker Protection and Best Available Science

Section 26 of TSCA requires EPA to use the best available science[3] and reasonably available information,[4] yet the draft risk evaluation does not comply with these requirements in key respects. The following areas should be re-examined to be compliant in this way. The draft risk evaluation fails this requirement currently in these significant respects:

- The assumption that workers in lithium ion cell manufacturing operations handle NMP without gloves is inappropriate (and violates OSHA requirements);

[3] Section 26(h) states, in part, that "to the extent that the Administrator makes a decision based on science, the Administrator shall use scientific information, technical procedures, measures, methods, protocols, methodologies, or models, employed in a manner consistent with the best available science."

[4] Section 26(k) requires the Administrator to "take into consideration information relating to a chemical substance or mixture, including hazard and exposure information, under the conditions of use, that is reasonably available to the Administrator." In addition, EPA's risk evaluation framework rule states that the agency will "base each risk evaluation on reasonably available information." 40 C.F.R. § 702.41(b).

- EPA should no longer employ the use of a PBPK model that is no longer commercially supported and has been modified from its original source in unknown ways, making it completely inaccessible to the public to assess exposures;

- EPA needs to consider and incorporate details on task durations and frequencies that show task durations are short and time limited. EPA cannot erroneously assume workers are exposed throughout their entire work shift rather than episodically handling NMP while protected by engineering controls and/or PPE;

- For occupational dermal exposure scenarios, EPA has selected assumptions that result in very high-end estimates of risk that do not represent actual conditions in the workplace (See Table 4-48);

- In the draft risk evaluation, EPA's default assumption is that the total skin surface area of hands is in contact with the liquid product. Again, for the high-end scenario, EPA assumes two full hands in contact with the liquid product for a full shift (8 to 12 hours). For the central tendency exposure, EPA assumes half of the area of both hands (palm side), was in contact with the liquid for half of a full shift (4 to 6 hours) (p. 227). These assumptions result in exposure scenarios driven by dermal contact with the liquid (see Table 4-49) that would require complete immersion in NMP liquid for several hours at a time. In most scenarios, 100% of the AUC (*i.e.*, internal dose) is due to direct and extended dermal contact, including tasks such as maintenance, truck unloading, and fabrication. EPA has not appropriately justified these dermal exposure assumptions for these occupational scenarios;

- EPA must consider the described engineering controls and chemical handling procedures – designed to prevent *any* dermal contact with liquid NMP or other potential forms of residual NMP – in presentations and in written documentation that has been submitted to EPA;

- The Agency's application of a safety factor of 10 to the skin surface area because "workers . . . are likely to wear gloves" and employees are likely to "have at least basic training on glove usage" is not appropriate either. EPA should find that no skin surface area is available for direct liquid dermal contact by workers for the purpose of this risk evaluation and that PPE is required per OSHA regulations;

- When modeling potential skin exposure, EPA did not reference the use of chemically resistant gloves. EPA must take the use of these gloves into consideration as they are required for our industry; and

- The PBPK model should be available for use by interested and affected parties. This information should include the PBPK code used for this assessment, model input parameters, and tabular outputs.

The draft conclusions in this risk evaluation should not be allowed to stand, consistent with TSCA, where best available science has not been used.

IX. Request for Relief

These comments are provided to supply more extensive and improved information for EPA to evaluate NMP in lithium ion cell manufacturing. Our information establishes that robust engineering controls and worker protection are implemented by the lithium ion cell manufacturing industry to prevent worker exposure to NMP. We ask EPA to use our information to conduct a stand-alone evaluation and find that there is no unreasonable risk to workers for this condition of use.

We also welcome the opportunity to meet with you in the coming weeks and months to discuss these comments and answer any follow-up questions you may have. The Coalition is willing to host EPA personnel on a tour of one of our lithium ion cell manufacturing facilities to show the agency firsthand the comprehensive protective measures that we use to protect our workers. Please contact Martha Marrapese at Wiley Rein LLP (202.719.7156 or mmarrapese@wiley.law) about any of these offers of assistance.

Thank you for the opportunity to provide these comments to demonstrate why we think the robust controls and protections that the lithium ion cell manufacturing industry uses prevent exposure to NMP and allow these operations to meet the safety standard of TSCA.

Respectfully Submitted,

Martha Marrapese, Esq.
On Behalf of The Lithium Ion Cell Manufacturers' Coalition

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ATTACHMENT B

wiley

Lithium Ion Cell Manufacturers' Coalition

Meeting with EPA on the Draft Risk Evaluation for NMP

March 25, 2020

Introductions

EPA

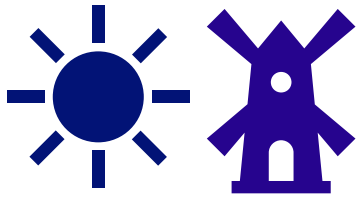
Members of Lithium ion Cell Manufacturers' Coalition

- Alliance for Automotive Innovation
- EnerSys
- Integer
- Panasonic Energy of North America
- PRBA – The Rechargeable Battery Association
- SAFT America

Industries Affected by NMP Risk Evaluation – Lithium Ion Cell Manufacturing

Automotive

Electric Vehicles

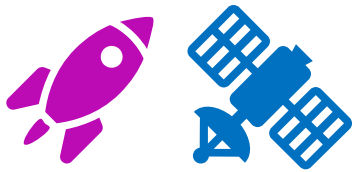


Energy Storage

Renewable energy

Medical Devices

Includes all critical hospital equipment



Aerospace

Aviation

Defense

Why We Are Here

- To explain the large and small scale processes for lithium ion cell manufacturing.
- To fill data gaps on the selection and use of PPE to prevent exposure to NMP in our industry.
- To explain why exposure scenarios used to find an unreasonable risk in the manufacturing of lithium ion cells are not accurate.
  - There is no direct hand contact with NMP in our industry;
  - Companies protect workers by using engineering controls and requiring PPE; and
  - Engineering controls and PPE are also needed to protect processes from impurities.

Lithium Ion Cell Manufacturing Practices – Large Scale Operations

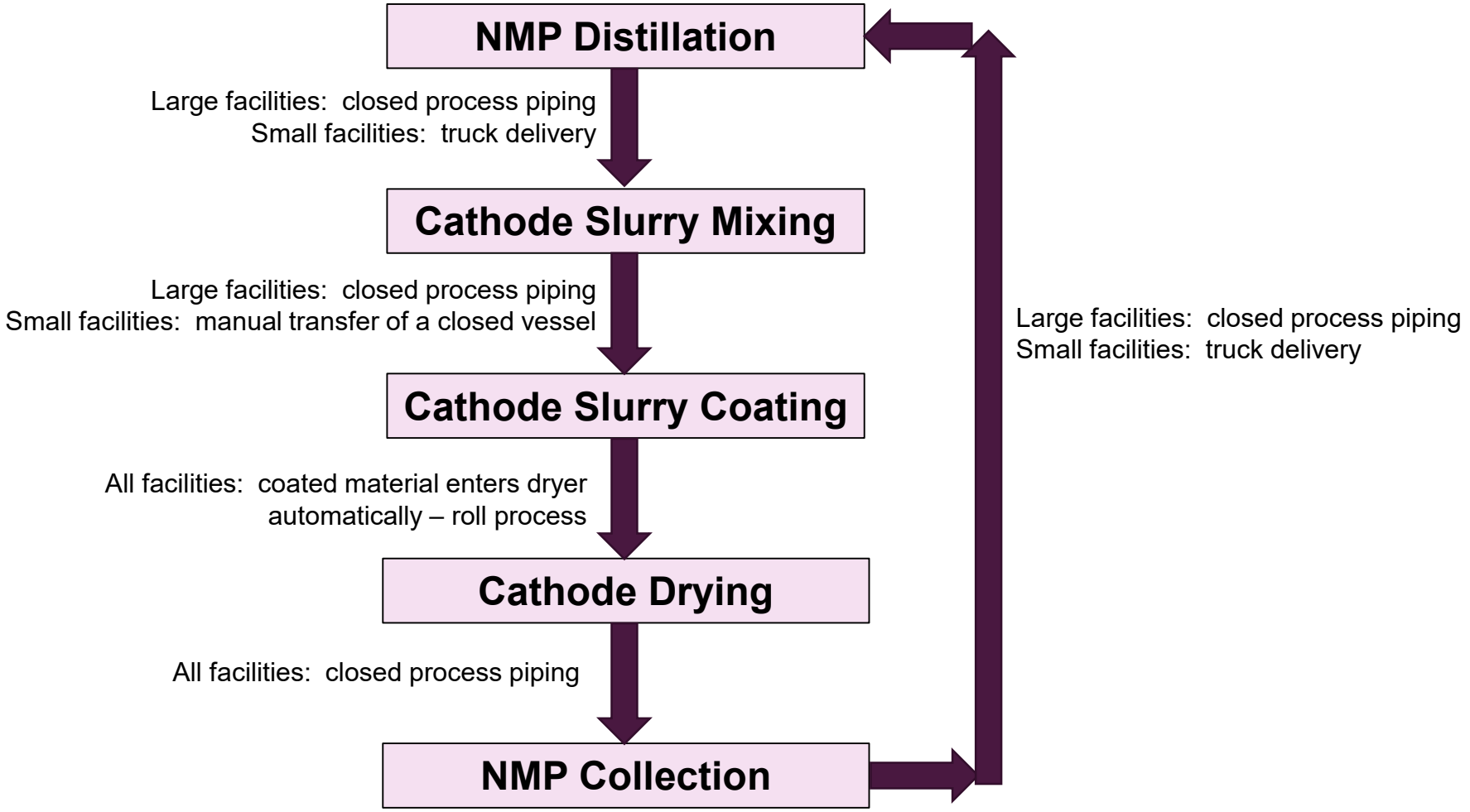
Overview of manufacturing processes

NMP is recovered and recycled on-site

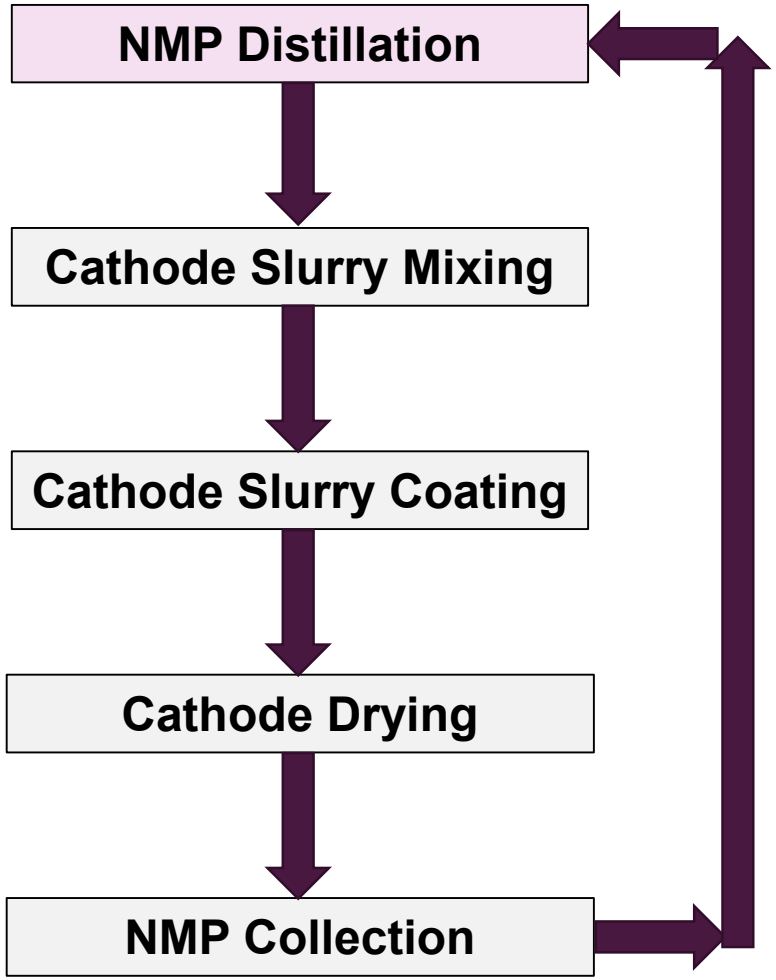
Exposure not anticipated in closed reactor formulation system

NMP Cycle

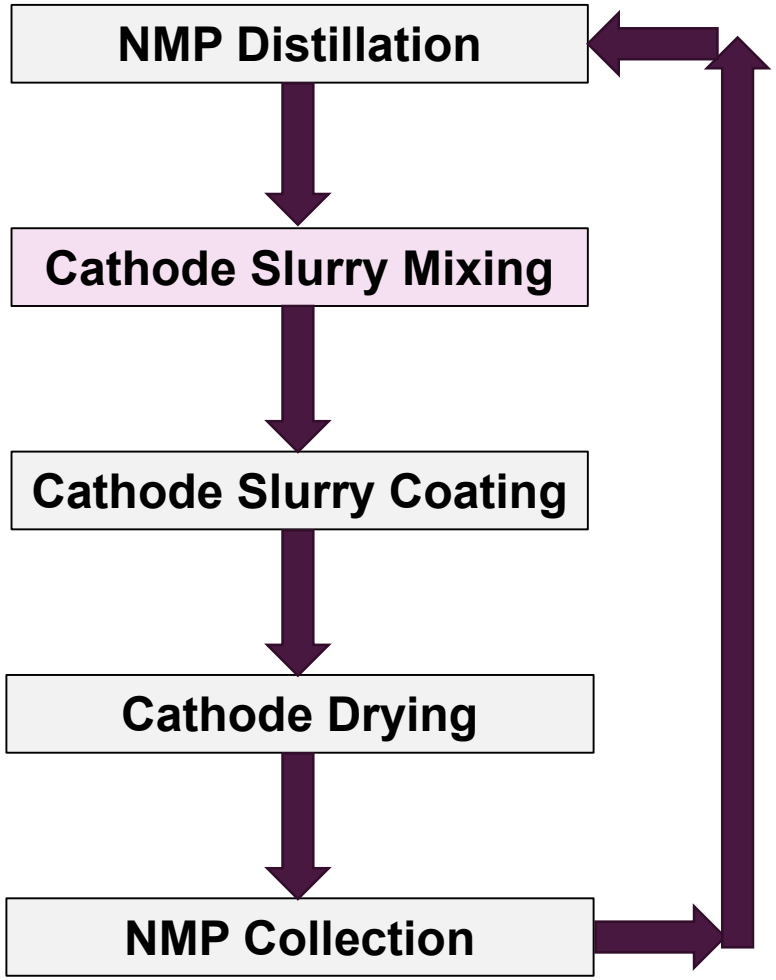
- All process steps are closed processes – operators tend the machines that conduct the processes, they do not perform these processes manually
- Operator exposure is prevented by use of engineering controls
- Maintenance procedures may rely on both engineering controls and PPE to prevent exposure



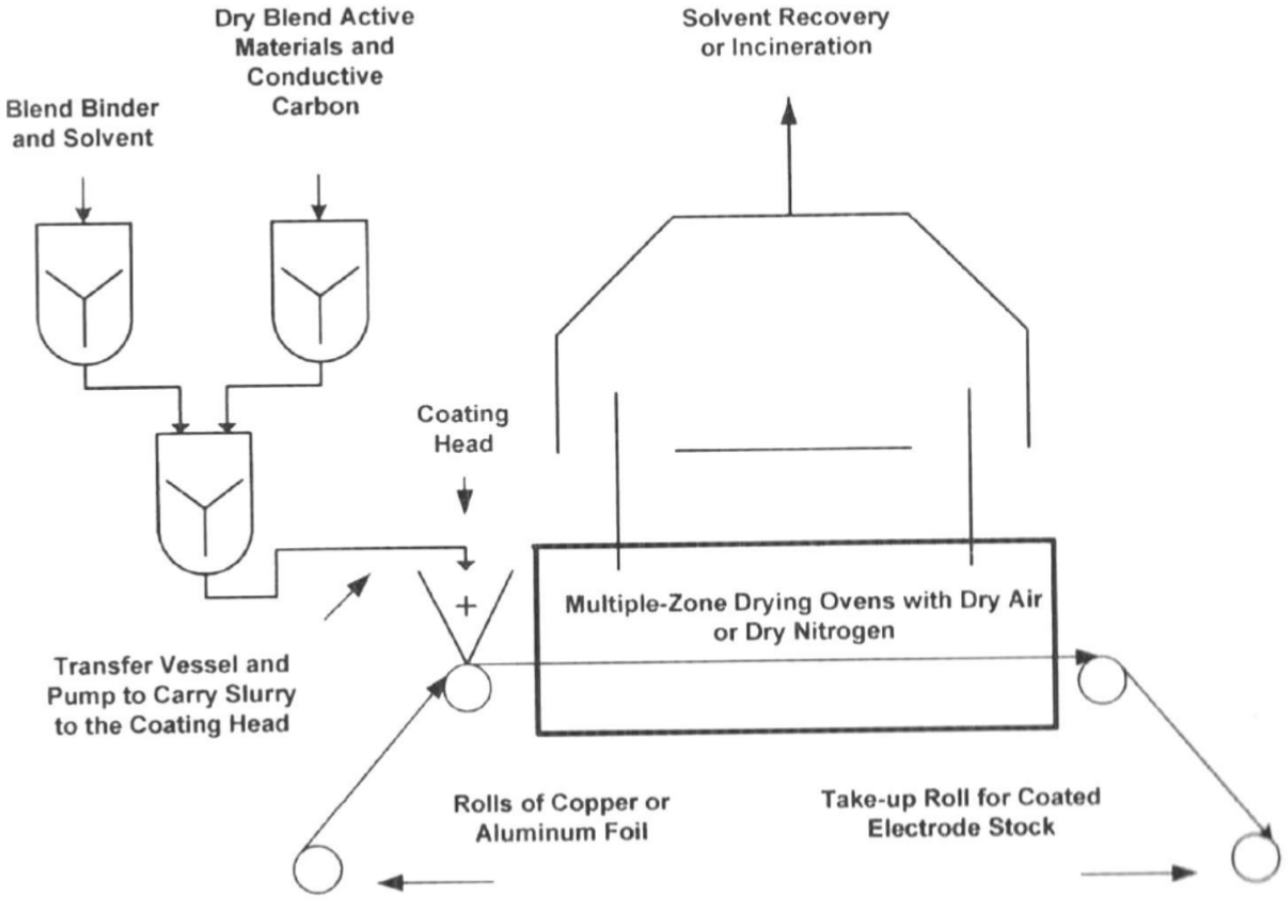
NMP Cycle - Distillation

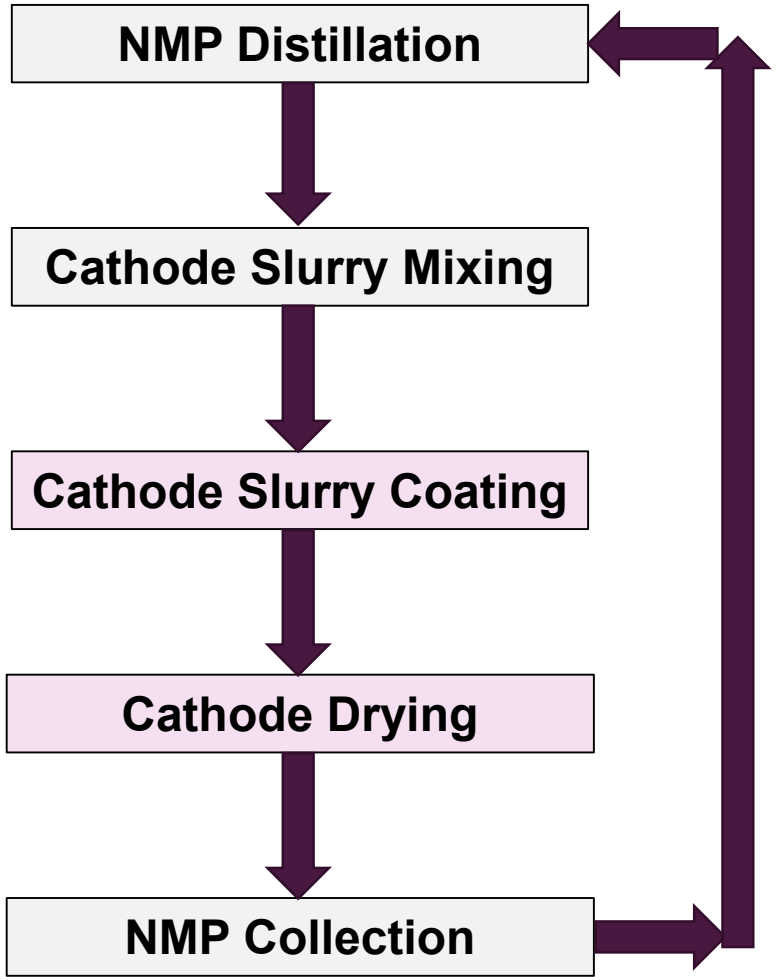


NMP Cycle - Mixing

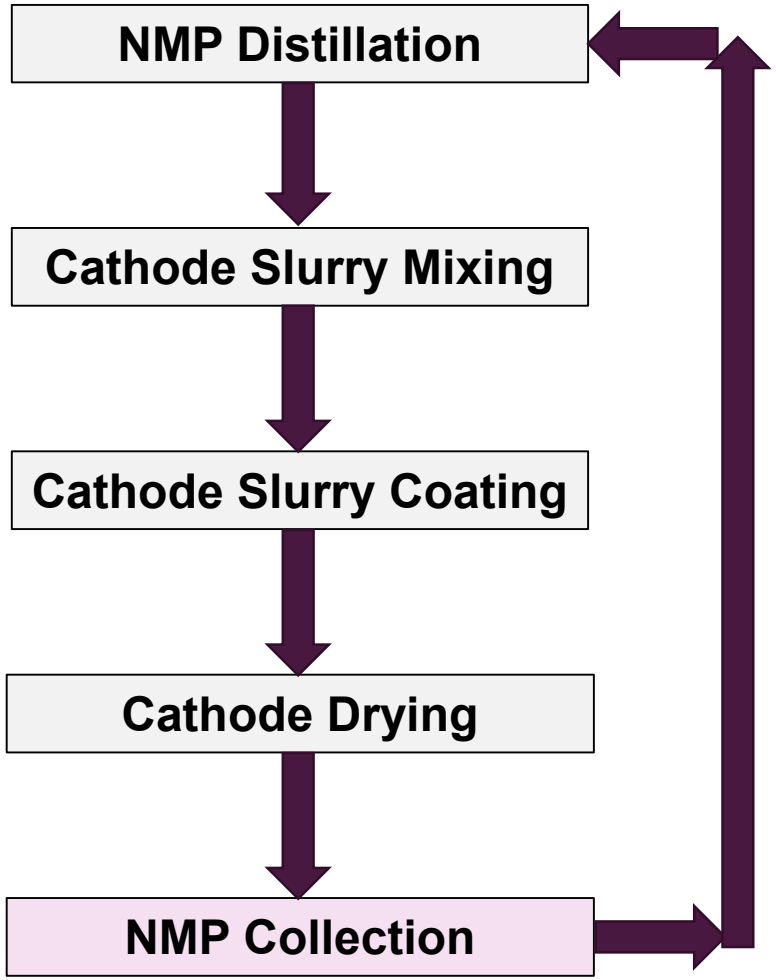


NMP Cycle – Coating & Drying





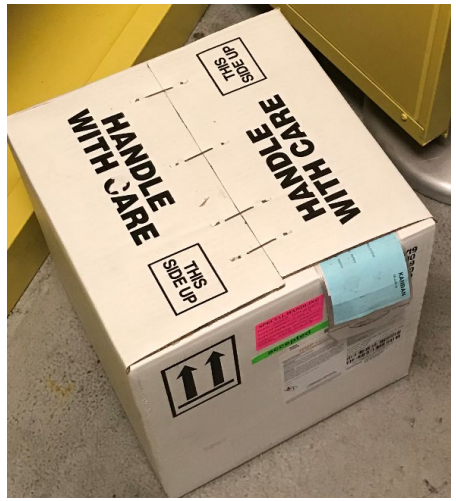
NMP Cycle - Collection

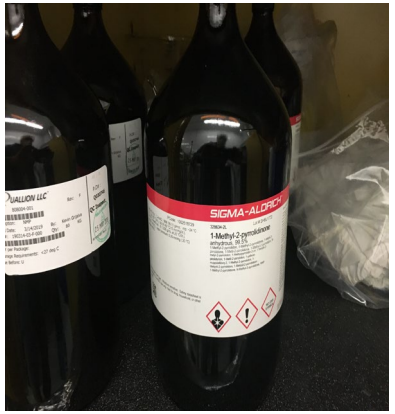


Lithium Ion Cell Manufacturing Practices – Small Scale Operations

- Overview of manufacturing process similar to large scale production, with some exceptions:
  - NMP received in 1-gallon sealed containers in a DOT-approved hazmat shipping box. Stored securely.
  - NMP prep and mixing is performed under appropriate ventilation with appropriate PPE.
  - Small volumes of NMP waste is generated. Waste is managed following all hazardous waste rules and collected by a contracted waste handler who properly packages and transports off-site for disposal.

Small Container Shipments of NMP





Potential Exposure Scenarios

EPA found an unreasonable risk for the following exposure scenarios:

- Small container handling;
- Virgin NMP truck unloading; and
- Waste truck loading.

Large scale v. small scale operating exposure scenarios

- Small container handling in small scale operations
- No direct exposure to NMP by cell manufacturing employees during unloading (vendor/sealed containers) or RCRA waste disposal.
- Large-scale operations recover and recycle NMP.

EPA model assumptions for continued direct contact

- This exposure scenario does not exist for this industry

Engineering Controls and PPE modeling assumptions

- To be discussed next.

Product Integrity

Necessity of product integrity

Closed Systems

Necessary PPE for safety and product integrity

Importance of Purity of Electrodes

- SEI layer on the anode
  - Determines cell performance metrics like: cycle life, calendar life, rate capability, resistance to lithium plating and thermal runaway reactions
  - SEI structure is strongly affected by low concentration additives or impurities

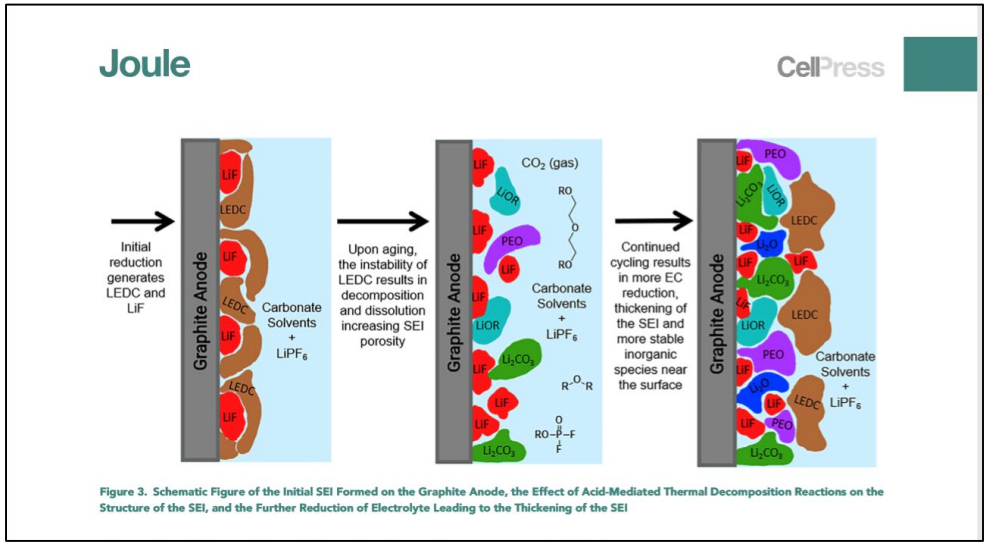


Figure 3. Schematic Figure of the Initial SEI Formed on the Graphite Anode, the Effect of Acid-Mediated Thermal Decomposition Reactions on the Structure of the SEI, and the Further Reduction of Electrolyte Leading to the Thickening of the SEI

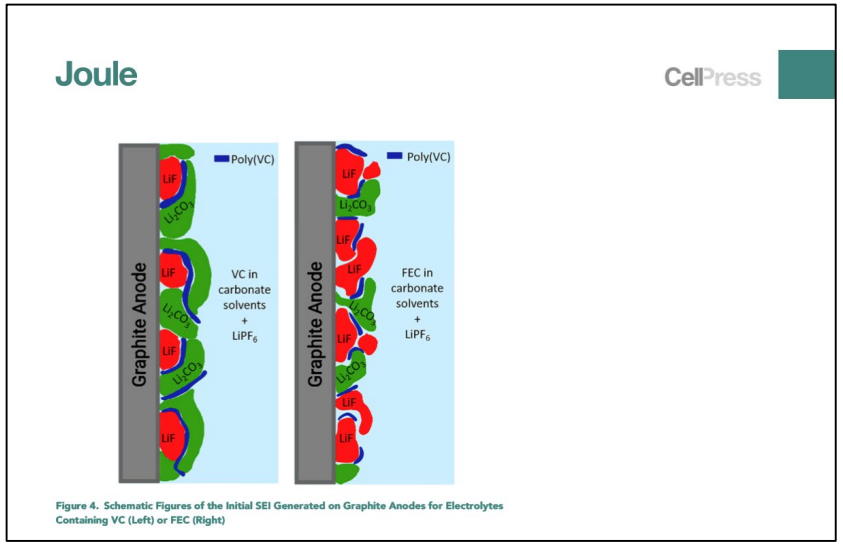
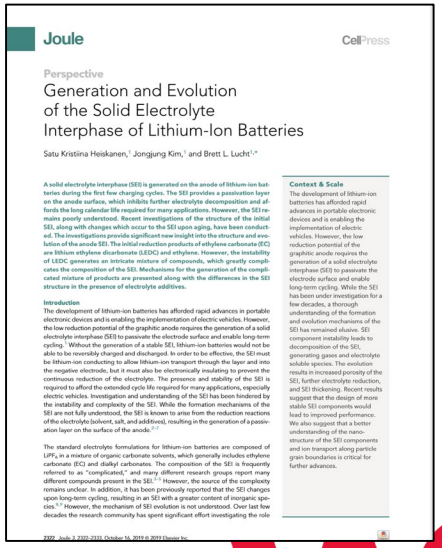


Figure 4. Schematic Figures of the Initial SEI Generated on Graphite Anodes for Electrolytes Containing VC (Left) or FEC (Right)



Importance of Purity of Electrodes

Y. Qian et al. Energy Storage Materials 20 (2019) 208–215

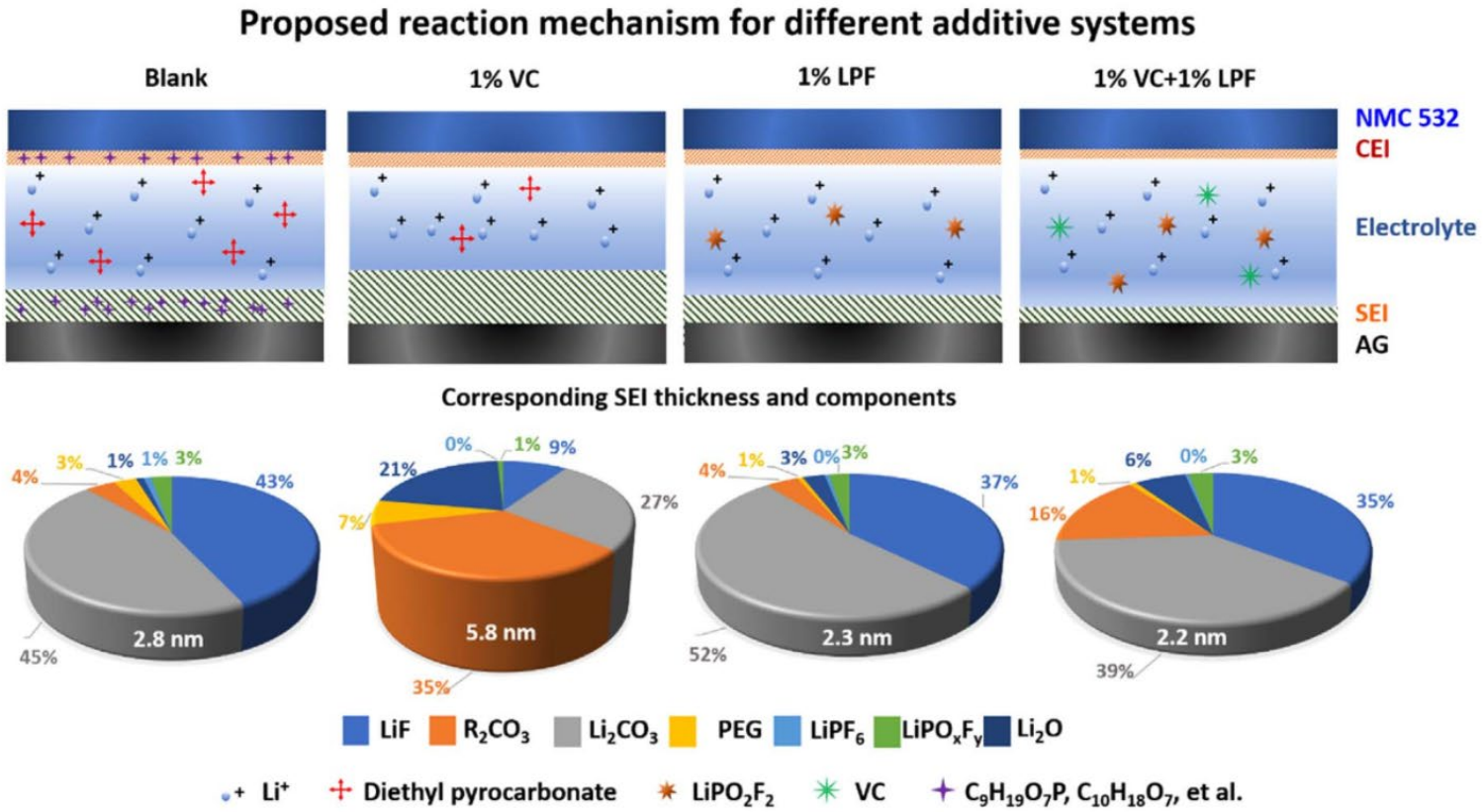


Fig. 5. Proposed reaction mechanism of different additives on the SEI & CEI formation and electrolyte decomposition of NMC532/AG pouch bag cells, with the specific atomic ratio of different components in the corresponding SEI on the anode.

"Additives that only present in electrolytes at trace concentrations are often used by the industry to alter the interphasial chemistry."

Worker Protection

Large Scale: Operations
- Trained operators, SOPs
- Process piping
- Automated, closed systems
- **PPE to prevent contamination, incidental contact possible but not SOP**
  - Light Tyvek
  - Safety glasses
  - Nitrile gloves
  - Safety shoes
  - Surgical mask
  - Hairnet and bump cap

Small Scale: Operations
- Trained operators, SOPs
- Manual transfers – small bottles
- Fume hoods
- Closed systems
- **PPE to prevent contamination, & brief (~30 minutes) of contact using gloves, no immersion**
  - Goggles / face shield
  - Butyl gloves over nitrile
  - Aprons

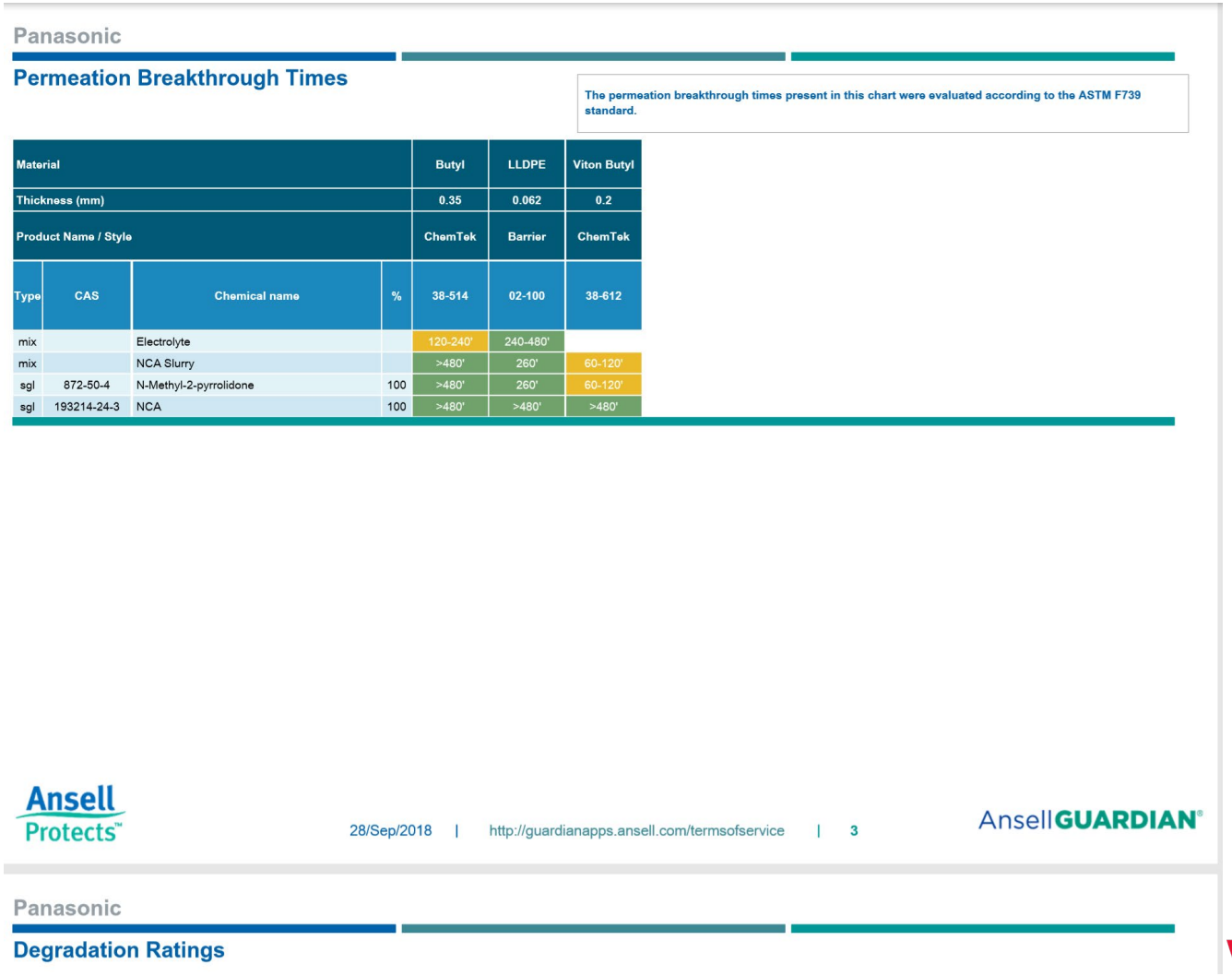
Large & Small Scale: Maintenance
- Trained maintenance techs & engineers
- Detailed SOPs
- Fume hoods, fume extractors, jigs
- Lockout Tagout protocols
- Confined Space protocols
- **PPE to prevent contact for up to 240 min (4 hours), less than ~ 10 min immersion**
  - Heavy Tyvek / or aprons
  - PAPR or respirator / goggles
  - Heavy butyl gloves over lighter gloves
  - Safety shoes

Engineering Controls

PPE

PENA, Glove Selection Process

- Glove selection involved analysis by glove manufacturers



Panasonic

Permeation Breakthrough Times

The permeation breakthrough times present in this chart were evaluated according to the ASTM F739 standard.

Material				Butyl	LLDPE	Viton Butyl
Thickness (mm)				0.35	0.062	0.2
Product Name / Style				ChemTek	Barrier	ChemTek
Type	CAS	Chemical name	%	38-514	02-100	38-612
mix		Electrolyte		120-240'	240-480'	
mix		NCA Slurry		>480'	260'	60-120'
sgl	872-50-4	N-Methyl-2-pyrrolidone	100	>480'	260'	60-120'
sgl	193214-24-3	NCA	100	>480'	>480'	>480'

Ansell Protects™ 28/Sep/2018 | http://guardianapps.ansell.com/termsofservice | 3 AnsellGUARDIAN®

Panasonic

Degradation Ratings

PENA, Glove Selection Process

- Glove selection involved analysis by glove manufacturers

ISO 9001 Registered
GUARDIAN
We Protect Hands

George,

After looking over independent studies/tests, reviewing past customers experiences/history, Guardian Manufacturing feels confident that a 7mil butyl glove would offer great dexterity for the customer, as well as superior chemical protection. See below for a screen shot of test results from an independent lab.

R = reusable S = single use	Material	Breakthrough time of neat NMP (min)	Thickness (mm)
R	Butyl rubber	480	0.7
R	Butyl rubber	480	0.3

You will notice that both of these gloves have fantastic hold out and actually both maxed out the test at 8 hours. Both of these gloves vary in thickness yet the butyl held out the NMP. We have no reason to believe a Guardian 7mil butyl glove would preform any differently.

Sincerely,

Pam Beckham

Date: 11/30/2017

Pam Beckham, Quality Assurance Manager

Glove Selection – Ansell Vendor

8th EDITION Permeation/Degradation Resistance Guide for Ansell Gloves

The first square in each column for each glove type is color coded to provide an overall rating for both Degradation and Permeation. The letter in each colored square is for Degradation alone.

- GREEN: The glove is very well suited for application with that chemical.
- YELLOW: The glove is suitable for that application under careful control of its use.
- RED: Avoid use of the glove with this chemical.

SPECIAL NOTE: The chemicals in this guide highlighted in BLUE are experimental carcinogens, according to the ninth edition of Sax' *Dangerous Properties of Industrial Materials*. Chemicals highlighted in GRAY are listed as suspected carcinogens, experimental carcinogens at extremely high dosages, and other materials which pose a lesser risk of cancer.

CHEMICAL	LAMINATE FILM BARRIER™			NITRILE SOL-VEX®			UNSUPPORTED NEOPRENE 29-SERIES			SUPPORTED POLYVINYL ALCOHOL PVA™			POLYVINYL CHLORIDE (Vinyl) SNORKEL®			NATURAL RUBBER *CANNERS AND HANDLERS™			NEOPRENE/ NATURAL RUBBER BLEND *CHEMI-PRO®			BUTYL UNSUPPORTED CHEMTEK™ BUTYL			VITON/BUTYL UNSUPPORTED CHEMTEK™ VITON/BUTYL		
	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate
102. Methylene Bromide (DBM)	▲	>480	E	NR	—	—	NR	—	—	G	>360	E	NR	—	—	NR	—	—	NR	—	—	E	70	F	E	>480	E
103. Methylene Chloride (DCM)	E	20	VG	NR	—	—	NR	—	—	G	>360	E	NR	—	—	NR	—	—	NR	—	—	G	13	P	E	29	G
104. Methylene bis(4-Phenylisocyanate) (MDI)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	▲	>480	E	▲	>480	E	—	—	—	—	—	—
105. Methyl Ethyl Ketone (MEK)	▲	>480	E	NR	—	—	P	—	—	F	90	VG	NR	—	—	F	5	F	P	<10	F	E	183	G	DD	20	G
106. Methyl Ethyl Ketone (MEK)/Toluene, 1/1	▲	>480	E	—	—	—	—	—	—	—	—	—	—	—	—	F	5	F	—	—	—	F	60	—	—	—	—
107. Methyl Iodide (Iodomethane)	▲	>480	E	NR	—	—	NR	—	—	F	>360	E	NR	—	—	NR	—	—	NR	—	—	F	15	P	G	215	VG
108. Methyl Isobutyl Ketone (MIBK)	▲	>480	E	P	45	F	NR	—	—	F	>360	E	NR	—	—	P	—	—	P	—	—	E	245	G	DD	30	G
109. Methyl Methacrylate (MMA)	▲	>480	E	P	35	P	NR	—	—	G	>360	E	NR	—	—	P	—	—	NR	—	—	E	85	G	DD	10	F
110. N-Methyl-2-Pyrrolidone (NMP)	▲	>480	E	NR	—	—	NR	—	—	NR	—	—	NR	—	—	E	75	VG	F	47	VG	E	>480	—	DD	—	—
111. Mineral Spirits, Rule 66	▲	>480	E	E	>480	E	E	125	G	E	>360	E	F	150	VG	NR	—	—	G	23	G	—	—	—	—	—	—

Glove Selection – North Vendor

Chemical Name	CAS No.	Silver Shield			Viton			Butyl			Chemsoft			Nitrile			Natural Rubber		
		D	BT	PR	D	BT	PR	D	BT	PR	D	BT	PR	D	BT	PR	D	BT	PR
*Methylene Chloride**	75-09-2	E	>8 hrs	N/D	F	1 hr	7.32	P	I/D	I/D	P	I/D	I/D	P	4 min	766	I/D	I/D	I/D
Monoethanolamine	141-43-5	I/D	I/D	I/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D	I/D	I/D	I/D
Morpholine	110-91-8	E	>8 hrs	N/D	G	1.9 hrs	97	E	>16 hrs	N/D	I/D	I/D	I/D	P	48 min	206	I/D	I/D	I/D
Naphtha	8052-41-3	E	>8 hrs	N/D	I/D	I/D	I/D	I/D	I/D	I/D	E	>8 hrs	N/D	E	>6 hrs	N/D	I/D	I/D	I/D
n-Hexane	110-54-3	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D	E	>6 hrs	N/D	I/D	I/D	I/D	I/D	I/D	I/D
*Nitric Acid, 10%**	7697-37-3	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	> 8 hrs	N/D	E	> 8 hrs	N/D	E	>8 hrs	N/D
*Nitric Acid, 70%**	7697-37-2	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	P	23 min	NR	P	12 min	NR	P	>8 hrs	N/D
Nitrobenzene	98-95-3	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D	F	29 min	1.7	P	7 min	8.4
Nitromethane	75-52-5	I/D	I/D	I/D	I/D	I/D	I/D	E	>8 hrs	N/D	I/D	I/D	I/D	I/D	I/D	I/D	P	7 min	2.83
1-Nitropropane	108-03-2	E	>8 hrs	N/D	P	17 min	26.1	E	>8 hrs	N/D	I/D	I/D	I/D	P	12 min	29.5	I/D	I/D	I/D
n-Methyl-2-Pyrrolidone	872-50-4	I/D	I/D	I/D	I/D	I/D	I/D	E	8 hrs	N/D	I/D	I/D	I/D	F	1.45 hrs	0.388	F	1.26 hrs	3.14
n-Propyl Acetate	109-60-4	E	>8 hrs	N/D	I/D	I/D	I/D	F	2.7 hrs	2.86	I/D	I/D	I/D	P	17 min	72.5	I/D	I/D	I/D
Oxalic Acid	144-62-7	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D	G	I/D	I/D	I/D	I/D	I/D/

D = Degradation
BT = Breakthrough Time
PR = Permeation Rate

E = Excellent
G = Good
F = Fair
P = Poor

N/D = None Detected
I/D = Insufficient Data

Most common chemicals available through VWR.

Good for total immersion

Good for accidental splash protection and intermittent contact

Only use with extreme caution. Glove will fail with only short exposure

North offers ezGuide™, an interactive software program which is designed to electronically help you select the proper glove for use against specific chemicals. This "user friendly“ guide walks you step-by-step through the process to determine what type of glove to wear and its permeation resistance to the selected contaminant.

ezGuide can be accessed from the North web site, www.northsafety.com or ordered by e-mailing us at marketing@northsafety.com.

Degradation (D) is a deleterious change in one or more of the glove's physical properties. The most obvious forms of degradation are the loss of the glove's strength and excessive swelling. Several published degradation lists (primarily "The General Chemical Resistance of Various Elastomers" by the Los Angeles Rubber Group, Inc.) were used to determine degradation.

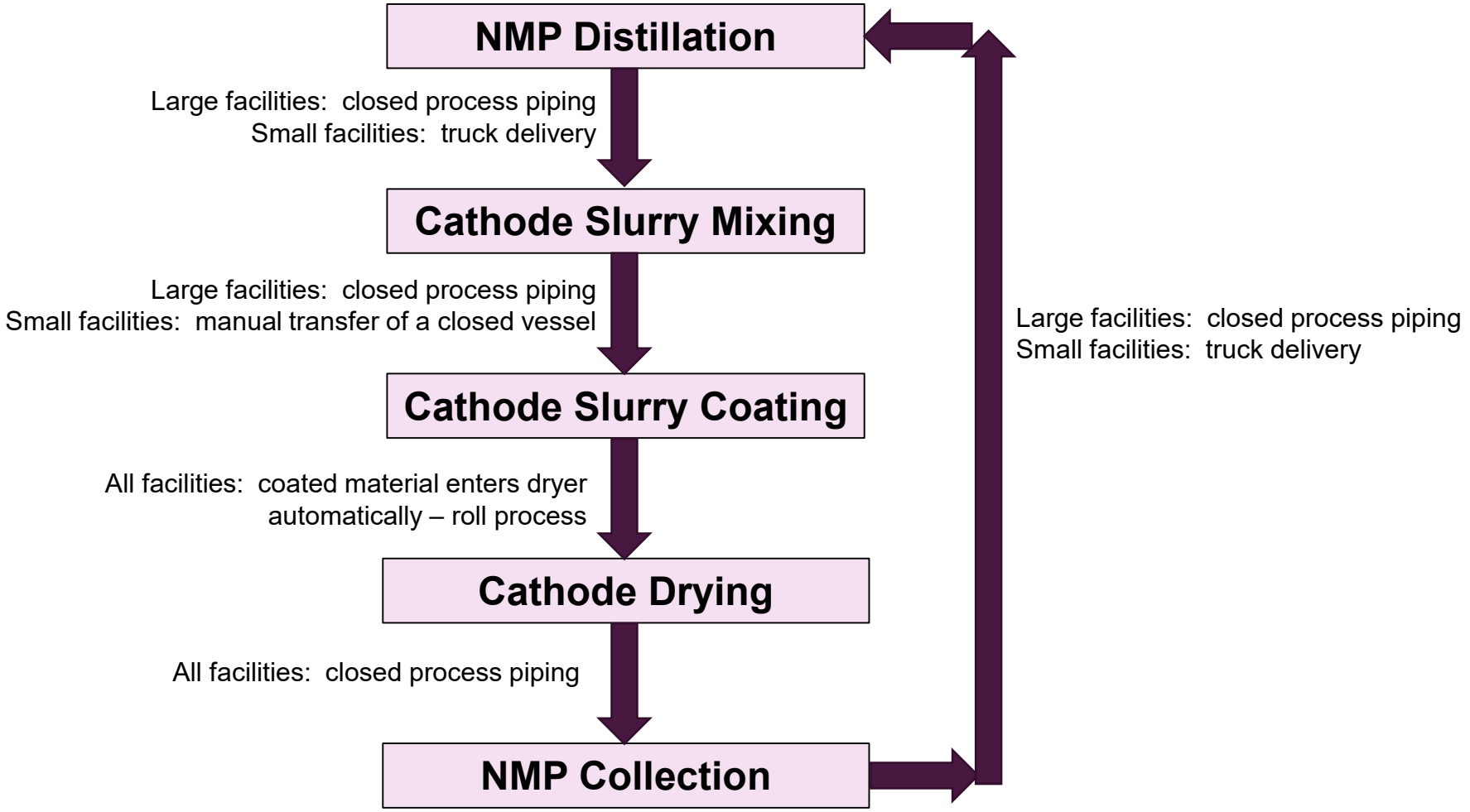
- **Breakthrough time (BT)** is defined as the elapsed time between initial contact of the liquid chemical with the outside surface of the glove and the time at which the permeation rate reaches 0.1 mg/m_2 /sec. WHEN BREAKTHROUGH OCCURS, THE GLOVE IS NO LONGER PROVIDING ADEQUATE PROTECTION.
- **Permeation rate (PR)**, measured in milligrams per square meter per second (mg/m2/sec) is the measured steady state flow of the permeating chemical through the glove elastomer. Glove thickness plays an important role in resistance to permeation.

Personal Protective Equipment

- PPE selection / criteria
  - Gloves
  - Hoods and respirators
  - Suits
  - Donning procedures and rooms
  - Selection support documentation
- Training
- Dedicated HSE management and coordination
- SOPs
- Incident reporting
- Insurance considerations

NMP Cycle

- All process steps are closed processes – operators tend the machines that conduct the processes, they do not perform these processes manually
- Operator exposure is prevented by use of engineering controls
- Maintenance procedures may rely on both engineering controls and PPE to prevent exposure



Summary

- No direct contact with NMP during unloading or waste handling in these operations.
  - For large scale operations, this task is performed by vendor.
  - Small scale operations receive DOT-compliant boxes of 1-gallon containers of NMP, securely stored, opened under engineering hood with PPE only. EPA model assumed direct contact for 4/8 hours. Direct contact does not occur in cell manufacturing at all.
- Engineering controls and appropriate PPE used at all times (as determined by proper PPE assessment).

Concentration and Frequency

- Large-scale operations
  - Slurry mixing is a continuous operation in a closed system.
  - Due to engineering controls and PPE, duration of direct exposure to NMP is zero.
- Small-scale operations
  - Slurry mixing is a batch operation performed on an infrequent basis for a few hours over the course of a couple weeks.
  - Due to engineering controls and PPE, duration of direct exposure to NMP is zero.

Questions for Discussion

- Is the agency re-running the PBPK model? If so, what are the inputs and assumptions? Are they different than before?
- How did EPA extrapolate that semiconductor manufacturing is similar to all other electronic parts manufacturing, including lithium ion cell manufacturing?
- How did EPA arrive at the assumption that lithium ion cell manufacturers unload and load NMP from trucks?
- What additional information, data, and documentation does EPA need from the coalition based on our comments and presentation?
- Would it be helpful to have a virtual tour of a lithium ion cell manufacturing facility? Why or why not?
- How would EPA like us to best provide information to support the issues raised in today's discussion? What is your timing?
- How does EPA consider the PPE selection information we have provided in relation to its protective factor criteria?

ATTACHMENT C

LITHIUM ION CELL MANUFACTURING INDUSTRY PBPK SUGGESTED MODELING PARAMETERS AND CONDITION OF USE INFORMATION									
ACTIVITIES	**SCALE OF OPERATIONS**	**CONTACT CONDITIONS**	**ENGINEERING CONTROLS**	**ADMINISTRATIVE CONTROLS (TRAINING AND SOPS)**	**GLOVES***	**OTHER PPE**	**DURATION OF TASK****	**NMP PURITY**	**ACTUAL DERMAL EXPOSURE**
Virgin NMP Truck Unloading	**Large operations**	**Third party** vendor transfers from tanker trucks to large, exterior tanks. Employees may set up safety perimeter, ensure safety during unloading process, and assist the driver at the beginning and end of the process.	Transferred to interior tanks via process piping, automated, closed systems.	See Maintenance Activities	See Maintenance Activities	See Maintenance Activities	See Maintenance Activities	> 99 %	**None**
Container Handling, Small Containers	**Small operations**	**Manual transfer.** Small bottles packaged in DOT compliant packaging, unopened.	DOT-compliant boxes of 1-gallon containers of NMP, securely stored.	Yes, including DOT-compliant inner and outer containers, as well as trained HAZWOPPER receiving teams	Receivers wear leather gloves (no expected exposure).	Safety glasses and lab coat	~30 minutes/month	> 99 %	**None**
	Small operations	**Mixing Prep.** Small containers used to prep mixture components for mixer or any small container use.	Engineering hood and fume extractors	Yes	Butyl (PPE to prevent contact for up to 240 minutes (4 hours)).	Safety glasses, lab coat, and butyl apron; or N95, face shield, and Tyvek Suit	30-60 minutes/day	> 99%	**None**
Container Handling, Small Containers and Drums	**Small operations**	**Transfer from process to drum.** Small bottles either (1) sealed and placed into 55-gallon drum or (2) transferred into a 55-gallon drum with spill containment.	Closed containers unless actively transferring waste.	Yes, RCRA waste-handling training	Butyl (PPE to prevent contact for up to 240 minutes (4 hours)).	Safety glasses and lab coat; transferring operation also uses N95 respirator, face shield, and butyl apron	30-60 minutes/month	Proprietary (=/<60%)	**None**
Container Handling, Drums	**Small operations**	**Transfer from drum to loading waste truck.** Drums torqued to seal and moved on drum dolly to storage location until ***third-party vendor*** loads truck for disposal.	Sealed 55-gallon drums.	Yes, RCRA waste-handling training	Latex (no expected exposure).	Safety glasses and lab coat	~30 minutes/month	Proprietary (=/<60%)	**None**
	Small operations	**Batch mixing.** Slurry mixture containing NMP mixed for consistency prior to application to metal foil. Semi-automated.	Closed systems, some process piping, ventilation controls.	Yes	Latex (no expected exposure; PPE to prevent product contamination).	Safety glasses, lab coat, and surgical mask	2-6 hours/day	Proprietary (=/<60%)	**None**
	Small operations	**Batch coating, and drying.** Fully automated.	Closed systems, process piping, ventilation controls.	Yes	Latex (no expected exposure; PPE to prevent product contamination).	Safety glasses, lab coat, and surgical mask	2-6 hours/day	Proprietary (=/<60%)	**None**

Cell Manufacturing	**Large operations**	**Batch mixing.** NMP added to slurry as a carrier via closed piping, slurry mixed for consistency prior to application to metal foil. Fully or semi-automated.	Fully automated systems - closed reactors, process piping, ventilation controls, manufacturing one or few types of cells. Semi-automated systems - same as above but greater operational flexibility needed, manufacturing different cell types.	Yes	Fully automated systems - nitrile (no expected exposure; PPE to prevent product contamination). Semi-automated systems - butyl over latex or nitrile (no expected exposure; PPE to prevent product contamination).	Fully automated - Light Tyvek, safety glasses, safety shoes, surgical mask, hairnet, and bump cap. Semi-automated - PAPR with hood and organic vapor/acid gas/HEPA combination cartridge.	12-hour shifts	Proprietary	**None**
	Large operations	**Batch coating, drying, and NMP recovery.** Fully automated.	Fully automated systems - closed reactors, process piping, ventilation controls, manufacturing one or few types of cells. Semi-automated systems - same as above but greater operational flexibility needed, manufacturing different cell types.	Yes	Fully automated systems - nitrile (no expected exposure; PPE to prevent product contamination). Semi-automated systems - butyl over latex or nitrile (no expected exposure; PPE to prevent product contamination).	Fully automated - Light Tyvek, safety glasses, safety shoes, surgical mask, harnet, and bump cap. Semi-automated - PAPR with hood and organic vapor/acid gas/HEPA combination cartridge.	12-hour shifts	Proprietary	**None**
Waste Truck Loading	**Small operations**	**Not applicable.** ***Third-party vendors*** load sealed drums onto trucks.	Sealed 55-gallon drums.	Yes	Licensed HazMat vendor PPE tailored to NMP/hazardous waste handling.	Not Applicable	Not Applicable	Not Applicable	**None**
	Large operations	**Not applicable.** Fully automated NMP recovery systems.	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	**None**
Maintenance Activities	**Small operations**	**Manual tasks.** Includes parts washing, equipment adjustments and repairs, and other non-routine tasks.	Fume extractors	Yes, SOPs and PMs, including OSHA Lockout Tagout and Confined Space protocols if applicable.	Butyl (gloves can withstand contact for up to 240 minutes (4 hours), but no exposure is expected).	Heavy Tyvek or butyl aprons, N95 or half face respirator, and safety glasses	~60 minutes/month	Proprietary (=/<60%)	**None**
	Large operations	**Manual tasks.** Includes preparation for unloading (no direct participation in unloading/response only), equipment adjustments and repair, parts washing, infrequent use of NMP to clean equipment parts.	Fume hoods, fume extractors, and jigs	Yes, including OSHA Lockout Tagout and Confined Space protocols.	Butyl over latex or nitrile (gloves can withstand contact for up to 240 minutes (4 hours), but no exposure is expected).	Heavy Tyvek or aprons, respirator or PAPR with hood and organic vapor/acid gas/HEPA combination cartridge, goggles, heavy butyl gloves over lighter gloves, and safety shoes	~60 minutes/month	> 99 % or Proprietary	**None**
Occupational	**Small operations**	NMP used in secured area. Process and safety checks and walk-throughs occur.	Closed Systems or Ventilation in place	Yes, including PPE donning requirements	Latex (no exposure expected; PPE to prevent product contamination)	Safety glasses, lab coat, surgical mask	~60 minutes/month	Proprietary (=/<60%)	**None**

Occupational Non-Users	**Large operations**	NMP used in secure area with fully-automated systems. Process and safety checks and walk-throughs occur.	Process piping, automated, closed systems.	Yes, including PPE donning requirements	Latex or nitrile (no exposure expected; PPE to prevent product contamination)	Light Tyvek or lab coat, safety glasses, safety covers for shoes, surgical mask, hairnet, and bump cap	~60 minutes/month	Proprietary	**None**

*** Glove selection is made by trained HSE professionals (IH or similar) based on information derived from permeation testing specific to the chemical, often in consultation with PPE vendors. Vendor standard recommendations were provided in the Lithium Ion Cell Manufacturers' Coalition's presentation to EPA on March 25, 2020.**

In its assessment of dermal exposure to NMP liquid, EPA used generic PF values of 5, 10, and 20 for gloves. Use of these PF values is inappropriate and does not reflect best available science considerations. It ignores available chemical-specific data, which show that the permeation rate of NMP can vary by more than 3 orders of magnitude, depending upon the material used in the gloves (nitrile ~ latex > polyethylene > butyl ~ laminate). The Lithium Ion Cell Manufacturers' Coalition urges EPA to avoid the use of general information and protection factors in modeling for our industry. We ask EPA to use/derive a material specific protection factor for the specific glove type (butyl) we use for job functions with potential for incidental dermal exposure to NMP based on available published permeation data for this glove type specific to NMP, such as that provided in the recent publication, "Using physiologically-based pharmacokinetic modeling to assess the efficacy of glove materials in reducing internal doses and potential hazards of N-methylpyrrolidone during paint stripping," by C. R. Kirman, which was published recently in the Journal of Exposure Science & Environmental Epidemiology (open access). See https://www.nature.com/articles/s41370-020-0218-2. Another study that looked at protective gloves for use with NMP-containing products found that butyl rubber gloves – such as those that are the standard for the lithium ion cell manufacturing industry – were the best choice (Crook and Simpson, 2007).

**** While the duration of a particular activity may, at times, provide the <u>potential for exposure</u>, there is <u>no actual exposure</u> to NMP during any of these tasks due to engineering controls and PPE.**

ATTACHMENT D

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May 22, 2020

Hon. Andrew Wheeler
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Ave. NW
Washington, DC 20460–0001

Re: Docket No. EPA-HQ-OPPT-2019-0236, Toxic Substances Control Act (TSCA) Draft Risk Evaluation for N-Methylpyrrolidone (NMP)

Dear Administrator Wheeler:

The Lithium Ion Cell Manufacturers' Coalition (Coalition) appreciates this opportunity to provide supplemental comments, through its counsel Wiley Rein LLP, to the U.S. Environmental Protection Agency (EPA) concerning the draft TSCA risk evaluation for NMP (Chemical Abstract Services Registry Number (CASRN) 872-50-4) noticed in the Federal Register on November 7, 2019. 84 Fed. Reg. 60087.[1]

Our members represent lithium ion cell[2] manufacturers and their downstream users. Lithium ion cells are used in many products that rely on rechargeable battery technology, such as electric cars, energy storage, medical devices, portable electronics, defense systems, and aerospace applications. Many of these cells are produced in facilities located across the United States, creating thousands of good-paying jobs and sustaining their surrounding communities.

The enclosed supplemental information further informs EPA's evaluation of NMP in relation to lithium ion cell manufacturing. This information documents how fully protective personal protective equipment (PPE) is selected and used in these operations when there is the potential for incidental exposure to NMP. Therefore, we specifically ask EPA to ensure this information is used to support and conduct a stand-alone occupational exposure evaluation for lithium ion cell manufacturing.

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[1] The Coalition is comprised of entities that manufacture and rely on lithium ion cell technology and the trade associations that support these industries. In alphabetical order, the Coalition participants are The Alliance for Automotive Innovation, Enersys, Integer, Panasonic, PRBA – The Rechargeable Battery Association, and Saft America.

[2] Even though EPA's draft risk evaluation used the word "battery," for the sake of accuracy, the Coalition's comments will use the technical term "cell" to describe the technology used in rechargeable batteries (which are comprised of one or more cells). Oftentimes, cells are manufactured in different facilities than batteries. The Coalition understands that EPA's draft risk evaluation intended to cover the manufacturing of lithium ion cells. NMP is used in cell manufacturing rather than during battery assembly.

I. Executive Summary

As EPA recognized in the draft risk evaluation, NMP is not a final component in lithium ion cells. It is mixed with powder chemicals in a slurry, which is coated onto thin metal foil in a precise, automated roll coating process (Roberts, 2017) used to create a cell cathode electrode. The NMP serves as a carrier for the binder resin in the slurry. The coated foil passes through dryers where the NMP is recovered. NMP does not remain in or on the lithium ion electrode or the final cell after the drying stage of the electrode manufacturing process. Lithium ion cells are produced in a tightly controlled manufacturing environment, and closed process piping systems are used for NMP transfer to prevent contamination of electrode slurry. Strict control of potential contaminants and humidity/dew point conditions is required to assure a high-quality final product. Thus, considerable effort is expended to prevent human contact with NMP or electrode slurries, both through the use of engineering controls and PPE.

The supplemental information provided with this letter explains the level of PPE and training that are used in lithium ion cell manufacturing, along with the nature of NMP loading and unloading at these facilities, which range from small to large scale operations. We recognize that a detailed explanation of these parameters is essential to accurately assess occupational exposure.

Previously, EPA evaluated the occupational exposure potential associated with the manufacturing of lithium ion cells together with the uses of NMP by several other industries. In so doing, the draft risk evaluation assumed that job activities and the use of PPE are the same or sufficiently similar as in these other industries. This is incorrect. We do not imply that these other manufacturing processes inadequately protect their workers. Rather, EPA should separately model and assess potential occupational exposure to NMP in lithium ion cell manufacturing with information specifically tailored to the activities of our industry, the engineering controls that we employ, and the PPE known to be used in these operations.

II. PPE Use, Selection, and Training

The supplemental information provided with this letter explains the level of PPE and training that are used in lithium ion cell manufacturing, along with the nature of NMP loading and unloading at these facilities, which range from small to large scale operations. Having a detailed explanation of these parameters is essential to the risk evaluation because they factor directly into the modeling the agency is conducting to assess worker safety.

As we have previously explained, the importance of purity and low moisture for lithium ion cathode production (compared to parts-washing, for example) distinguishes operations in which NMP is used for cleaning and removal activities. Because of purity concerns alone, *nowhere* in a commercial lithium ion cell manufacturing process are workers allowed to immerse their hands in NMP or NMP-based slurries – *with or without*

proper PPE.[3] The information we are providing demonstrates that the occupational exposure assessment in the draft risk evaluation is based on assumptions about the potential for exposure that do not actually exist in lithium ion cell manufacturing. Specifically, EPA's assumptions of no glove use or gloves with a PF of 5 or 10 when there is potential for incidental dermal exposure to NMP do not accurately reflect standard industry practice in these operations. Strong engineering controls prevent exposure to our workers, and where there is the potential for incidental dermal exposure to NMP, effective and appropriate PPE is used to prevent any contact with skin. Therefore, it would be inconsistent with the administrative record established over the course of this risk evaluation for EPA to rely on its assumed generic modeling parameters for lithium ion cell manufacturing.

More specifically, the selection of protective glove materials in lithium ion cell manufacturing is based on the recommendations of leading glove manufacturers. (Attachment A). This glove selection is also supported by well-conducted, published studies on the effectiveness of glove materials to prevent worker exposure to NMP.[4] In addition, we are providing representative worker training material to demonstrate that PPE requirements are effectively communicated and strictly followed for each activity where there is the potential for NMP exposure. (Attachment B). As shown in the training material, instruction in PPE is augmented by signage in the workplace, dedicated stations to don PPE, and the use of mixing air showers before entry into secured production areas.

Extensive engineering controls exist within large operations to prevent worker contact with NMP and NMP-containing slurry. Even small operations, however, take substantial care to prevent contact with NMP and NMP-containing slurry. To further demonstrate that workers in small operations do not come into contact with NMP when it is received, we are providing representative images of how NMP is delivered in packaging that is compliant with U.S. Department of Transportation regulations for the transport of hazardous materials. (Attachment C). These one-gallon containers are then securely stored until they are carefully transferred to the mixing room. Finally, we are providing representative images of the enclosed drums used by small operations to dispose of NMP as a waste. In some circumstances, small operators perform a controlled transfer from a small bottle of waste containing NMP into a 55-gallon drum, using an industrial-grade funnel with a sealable lid and spill containment. (Attachment D). In other circumstances, small operators place sealed small bottles into a 55-gallon drum. (Attachment D). The drums are then torqued to seal them and taken on a drum dolly to a secure storage

[3] For the record, EPA has issued several consent orders and associated significant new use rules (SNURs) for the use of cathode powders that already require the extensive use of PPE in cathode mixing operations during lithium ion cell manufacturing, such as 40 C.F.R. § 721.11027.

[4] Crook, V., Simpson, A. 2007. Protective glove selection for workers using NMP containing products - Graffiti removal. Health & Safety Laboratory. HSL/2007/41. http://www.hse.gov.uk/research/hsl_pdf/2007/hsl0741.pdf; Kirman, C.R., March 2020. Using physiologically-based pharmacokinetic modeling to assess the efficacy of glove materials in reducing internal doses and potential hazards of N-methylpyrrolidone during paint stripping. J. Expos. Science and Env. Epidem. https://www.nature.com/articles/s41370-020-0218-2.

location until a third-party vendor loads the drums onto a truck for disposal. Appropriate PPE is worn during both circumstances.

III. All Primary Limitations That Prevented Independent Assessment are Now Addressed

The information we have provided to EPA over the course of the risk evaluation now addresses all of the "Primary Limitations" identified by EPA in the Draft Risk Evaluation associated with evaluating the use of NMP during lithium ion cell manufacturing as follows:

- EPA acknowledged in the draft risk evaluation that "[s]kin surface areas for actual dermal contact are uncertain." (p. 104). The Coalition has established with certainty that there is no dermal contact to the skin surface area encountered in the workplace for lithium ion cell manufacturing.

- The draft risk evaluation also stated that "EPA did not find data on the use of gloves for this occupational exposure scenario and assumed glove usage is likely based on professional judgment, due to the highly controlled nature of electronics manufacturing." (p. 104). The information we are providing establishes how gloves are selected, the data supporting the appropriateness of the glove material selected, and the required use of this PPE when there is the slightest potential for incidental dermal exposure to NMP.

- EPA's draft risk evaluation for the electronics parts manufacturing category conceded that "[t]he assumed glove protection factor values are uncertain." (p. 104). The Coalition has previously urged EPA to avoid the use of general information and protection factors in modeling for our industry. Instead, we ask EPA to use or derive a material-specific protection factor for the actual glove type we use for job functions with the potential for incidental dermal exposure to NMP.

- The draft risk evaluation parameters included 8 or 12 hours as the high-end exposure duration and a mid-range of 4 or 6 hours as the central tendency exposure duration. EPA admitted that "[t]he representativeness of the estimates of duration of inhalation and dermal exposure for the assessed activities toward the true distribution of duration for all worker activities in this occupational exposure scenario beyond semiconductor manufacturing is uncertain." (p. 104). EPA now possesses information, however, that demonstrates that the duration of exposure should be *zero* because there is no actual exposure to NMP during our processes.

- The draft risk evaluation listed MOEs calculated based on high-end estimates of acute exposure to workers during NMP use in electronic parts manufacturing with a maximum PF value of 10 for glove use. (p. 242). EPA noted that "[a]lthough the MOE calculation incorporating a glove protection factor (PF 20) is above the benchmark MOE, EPA has not found information that would indicate specific activity training (e.g., procedure for glove removal and disposal) for tasks where dermal

exposure can be expected to occur. The PF 20 glove protection factor is not assumed for any central tendency or high-end estimates." If EPA decides to continue its approach of using general protective factors, however, it now has the information needed to assume a glove protection factor of 20 or higher for all estimated durations.

- For Occupational Nonusers (ONUs), the draft risk evaluation indicated the need for further information on the use of PPE and therefore did not assume the use of PPE by ONUs. (p. 254). With the information that our Coalition has provided to EPA, the risk evaluation can assume that ONUs use the appropriate level of PPE for the various activities of lithium ion cell manufacturing.

We understand that in the absence of sufficient information, EPA generally derived occupational exposures for lithium ion cell manufacturing based on assumptions from other, unrelated industries in the electronic parts manufacturing subcategory for occupational exposure. Given this information gap, EPA's draft risk evaluation preliminarily concluded that electronic parts manufacturing (which included lithium ion cell manufacturing) represented *high-end* occupational exposures with risks that are not mitigated by glove use. (p. 284). Having removed all these uncertainties, we have provided EPA with conclusive information that occupational exposure during lithium ion cell manufacturing actually presents the "lowest concern for human health risks." Indeed, our industry processes include a high level of containment in large and small operations, and in the small-scale use of NMP in operations with loading and waste handling activities. The conditions of use that EPA identifies as presenting a higher degree of concern – namely a lower level of containment, elevated temperatures, and high intensity use in cleaning or removal – are neither present nor relevant to lithium ion cell manufacturing.

IV. Clarification of Separate Evaluation Request

As noted, the Coalition specifically seeks separate occupational exposure modeling and separate occupational exposure subcategory treatment in the grouping of "Electronic parts manufacturing." This approach is consistent with the treatment of lithium ion cell manufacturing in the scope and draft risk evaluation as a separate condition of use subcategory. Specifically, the draft risk evaluation listed "lithium ion batteries" as a separate subcategory under the Category "Other Uses" for the "Industrial, commercial and consumer use" Life Cycle Stage in Table 1-6 on page 38. TSCA section 3(4) defines the term "conditions of use" as ''the circumstances, as determined by the Administrator, under which a chemical substance is intended, known, or reasonably foreseen to be manufactured, processed, distributed in commerce, used, or disposed of." Moreover, TSCA section 19(c)(1)(B) directs a court to hold unlawful an EPA risk evaluation and any corresponding risk management regulations if the court finds that the order and/or rule is not supported by substantial evidence in the record taken as a whole. Therefore, if EPA obtains and possesses sufficient information on how a chemical substance is known to be processed, the agency is required to rely on that information and not make generalized assumptions. To take a contrary approach would not only be arbitrary and capricious but would also violate the plain requirements of TSCA.

The Coalition has provided EPA with information sufficient to conduct an independent assessment and risk estimate, separate and apart from other electronic parts manufacturing industries that rely heavily on NMP for cleaning and stripping activities that are not relevant to lithium ion cell manufacturing. (*See* p. 29 of the draft risk evaluation ("NMP is a key cleaning component for the manufacture of semiconductors used in electronics, and for the manufacture of printed circuit boards.")). The potential for incidental dermal exposure to NMP in our industry is low due to engineering controls, administrative controls, the use of appropriate PPE and associated training, and the need to prevent product contamination.

V. Conclusion

In summary, we respectfully submit this information on EPA's key occupational exposure parameters associated with how NMP is handled during lithium ion cell manufacturing to (1) provide EPA with the basis for conducting a separate, independent evaluation of lithium ion cell manufacturing and (2) demonstrate that NMP does not present an unreasonable risk in lithium ion cell manufacturing because workers in our industry are protected from any exposure to NMP throughout our processes. We appreciate the EPA staff's time and attention to understanding this condition of use, and we remain available to answer any follow-up questions they may have.

Thank you for the opportunity to provide this supplemental information on practices that lithium ion cell manufacturing operations employ to ensure the safety of our workers and the integrity of our products.

Respectfully Submitted,

Martha Marrapese, Esq.
On Behalf of The Lithium Ion Cell Manufacturers' Coalition

Enclosures (4)

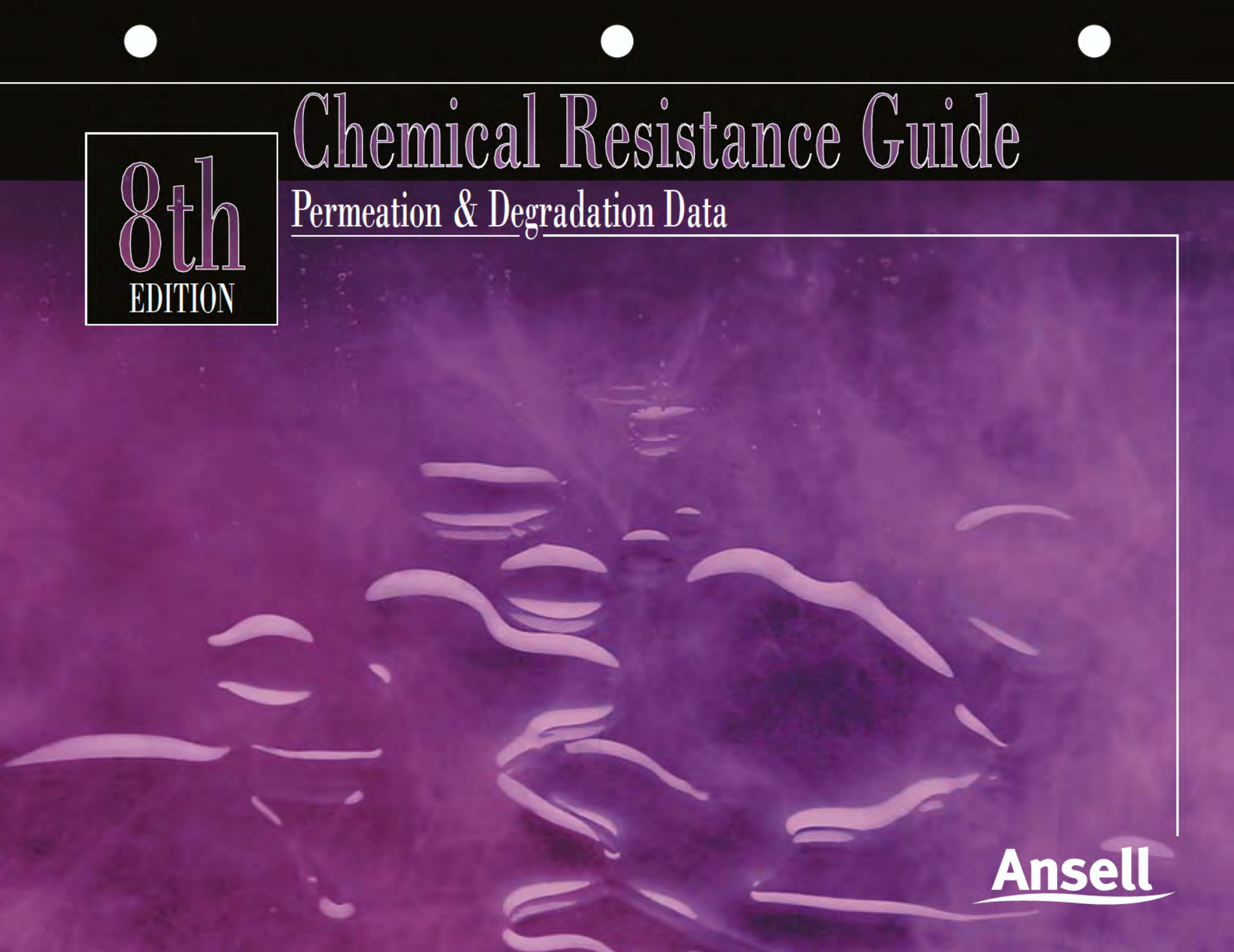
Attachment A

Examples of Glove Selection Guides and Analyses

Chemical Resistance Guide

Permeation & Degradation Data

8th EDITION



Ansell

Permeation/Degradation Resistance Guide for Ansell Chemical Resistant Gloves

Introduction to the 8th Edition

When reviewing the following recommendations, remember that tests are conducted under laboratory conditions, and that actual workplace conditions usually dictate a *combination* of performance capabilities. A product's resistance to cuts, punctures, and abrasion must also be taken into account as a critical usage factor. A glove with excellent permeation resistance may not be adequate if it tears or punctures easily. Always factor in the physical performance requirements of the job or application when selecting a chemical-resistant glove.

Ansell's ASTM standard permeation and degradation tests are presented on the following pages as an aid in determining the general suitability of various products for use with specific chemicals. Because the conditions of ultimate use are beyond our control, and because we cannot run permeation tests in all possible work environments and across all combinations of chemicals and solutions, these recommendations are advisory only. THE SUITABILITY OF THE PRODUCT FOR A SPECIFIC JOB MUST BE DETERMINED BY TESTING BY THE PURCHASER.

Definition of Key Terms

Permeation is a process by which a chemical can pass through a protective film without going through pinholes, pores, or other visible openings. Individual molecules of the chemical enter the film, and "squirm" through by passing between the molecules of the glove compound or film. In many cases the permeated material may appear unchanged to the human eye.

Chemical permeation can be described in simple terms by comparing it to what happens to the air in a balloon after several hours. Although there are no holes or defects, and the balloon is tightly sealed, the air gradually passes through (permeates) its walls and escapes. This simple example uses gas permeation, but the principle is the same with liquids or chemicals.

Permeation data are presented in two values: **Breakthrough** time and **Rate**. Breakthrough times (min.) are the times observed from the start of the test to first detection of the chemical on the other side of the sample (for test methodology, see the outside back cover of this guide). These times represent how long a glove can be expected to provide effective permeation resistance when totally immersed in the test chemical.

Permeation rates are the highest *flow rates* recorded for the permeating chemicals through the glove samples during a six-hour or eight-hour test. These qualitative ratings are comparisons of permeation rates to each other.

Degradation is a reduction in one or more physical properties of a glove material due to contact with a chemical. Certain glove materials may become hard, stiff, or brittle, or they may grow softer, weaker, and swell to several times their original size. If a chemical has a significant impact on the physical properties of a glove material, its permeation resistance is quickly impaired. For this reason, glove/chemical combinations rated "Poor" are usually not tested for permeation resistance, and combinations rated "Not Recommended" are never tested for permeation resistance. Please note, however, that permeation and degradation do not always correlate.

The overall **Degradation Rating** for each chemical is explained in "How To Read The Charts."

How to Read the Charts

Three categories of data are represented for each Ansell product and corresponding chemical: 1) overall degradation resistance rating; 2) permeation breakthrough time, and 3) permeation rate.

Standards for Color-Coding

A glove-chemical combination receives GREEN if either set of the following conditions is met:

- The Degradation Rating is Excellent or Good
- The Permeation Breakthrough Time is 30 minutes or greater
- The Permeation Rate is Excellent, Very Good, or Good

OR

- The Permeation Rating is not specified
- The Permeation Breakthrough Time is 240 minutes or greater
- The Degradation Rating is Excellent, or Good

A glove-chemical combination receives RED if either set of the following conditions is met:

- The Degradation Rating is Poor or Not Recommended

OR

- The Degradation Rating is Degrades with Delamination (DD)
- The Permeation Breakthrough Time is less than 20 minutes

All other glove-chemical combinations receive YELLOW. In other words, any glove-chemical combination not meeting either set of conditions required for Green, and not having a Red degradation rating of either Poor or Not Recommended, receives a YELLOW rating.

Why is a product with a shorter breakthrough time sometimes given a better rating than one with a longer breakthrough time?

One glove has a breakthrough time of just 4 minutes. It is rated "very good," while another with a breakthrough time of 30 minutes is rated only "fair." Why? The reason is simple: in some cases the *rate* is more significant than the *time*.

Imagine connecting two hoses of the same length but different diameters to a faucet using a "Y" connector. When you turn on the water, what happens? Water goes through the smaller hose first because there is less space inside that needs to be filled. But when the water finally gets through the larger hose it really gushes out. In only a few minutes, the larger hose will discharge much more water than the smaller one, even though the smaller one started first.

The situation is similar with gloves. A combination of a short breakthrough time and a low permeation rate may expose a glove wearer to less chemical than a combination of a longer breakthrough time and a much higher breakthrough rate, if the glove is worn long enough.

Key to Permeation Breakthrough

>Greater than (time) <Less than (time)

Key to Degradation Ratings

E – Excellent; fluid has very little degrading effect.
G – Good; fluid has minor degrading effect.
F – Fair; fluid has moderate degrading effect.
P – Poor; fluid has pronounced degrading effect.
DD – Degrades the outer layer and delaminates it.
NR – Not Recommended; fluid has severe degrading effect.

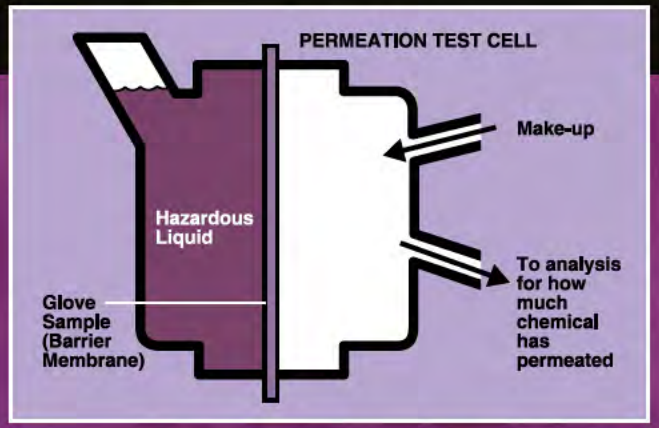
DD is a new degradation rating that applies to Viton/butyl gloves versus certain chemicals. It means "Degrades and Delaminates". If a chemical causes severe swelling of Viton but has little effect on butyl, the adhesion between these two rubber layers can be overcome under the relatively severe continuous liquid contact that is part of an ASTM or CEN standard permeation test. The end result of this stress is Viton "blisters" or even complete layer separation. The damage is likely to be permanent.

In cases such as these the butyl layer is providing most of the protection. But if the end use involves only the possibility of splash or intermittent contact so that the Viton layer never absorbs enough chemical to swell and delaminate, Viton/butyl gloves might still be the best choice. The ultimate decision on when to use plain butyl and when to use Viton/butyl will depend on the overall chemical mix in your facility and on the degree of exposure to each.

Specific Gloves Used for Testing

	Degradation and Permeation
Laminated LCP™ Film	Barrier® 2-100 (2.5 mil/0.06 mm)
Nitrile	Sol-Vex® 37-165 (22 mil/0.56 mm)
Neoprene Unsupported	29-865 (18 mil/0.46 mm)
Polyvinyl Alcohol Supported	PVA™
Polyvinyl Chloride Supported	Snorkel®
Natural Rubber Latex	Canners 343 (20 mil/0.51 mm)
Neoprene/Latex Blend	Chemi-Pro® 224 (27 mil/0.68 mm)
Butyl Unsupported	ChemTek® 38-320 (20 mil/0.51 mm)
Viton/Butyl Unsupported	ChemTek® 38-612 (12 mil/0.30 mm)

Methodology



Permeation Testing

Ansell conducts permeation testing in accordance with ASTM Method F 739 standards. A specimen is cut from the glove and clamped into a test cell as a barrier membrane (see illustration). The "exterior" side of the specimen is exposed to a hazardous chemical. At timed intervals, the unexposed "interior" side of the test cell is checked for the presence of the permeated chemical and the extent to which it may have permeated the glove material.

This standard allows a variety of options in analytical technique and collection media. At Ansell, dry nitrogen is the most common medium and gas chromatography with FID detection is the most common analytical technique. Our Research Department also uses liquids such as distilled water and hexane as collecting media, and techniques such as conductivity, colorimetry, and liquid chromatography for analysis of the collecting liquid.

Degradation Testing

Patches of the test material are cut from the product. These patches are weighed and measured, and then completely immersed in the test chemical for 30 minutes. The percentage of change in size is determined, and the patches are then dried to calculate the percentage of weight change. Observed physical changes are also reported. Ratings are based on the combined data.

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8th Edition Form No. CRG-GC. 9/08

8th EDITION Permeation/Degradation Resistance Guide for Ansell Gloves

The first square in each column for each glove type is color coded to provide an overall rating for both Degradation and Permeation. The letter in each colored square is for Degradation alone.

- GREEN: The glove is very well suited for application with that chemical.
- YELLOW: The glove is suitable for that application under careful control of its use.
- RED: Avoid use of the glove with this chemical.

SPECIAL NOTE: The chemicals in this guide highlighted in BLUE are experimental carcinogens, according to the ninth edition of Sax' *Dangerous Properties of Industrial Materials*. Chemicals highlighted in GRAY are listed as suspected carcinogens, experimental carcinogens at extremely high dosages, and other materials which pose a lesser risk of cancer.

CHEMICAL	LAMINATE FILM BARRIER™			NITRILE SOL-VEX®			UNSUPPORTED NEOPRENE 29-SERIES			SUPPORTED POLYVINYL ALCOHOL PVA™			POLYVINYL CHLORIDE (Vinyl) SNORKEL®			NATURAL RUBBER *CANNERS AND HANDLERS™			NEOPRENE/ NATURAL RUBBER BLEND *CHEMI-PRO®			BUTYL UNSUPPORTED CHEMTEK™ BUTYL			VITON/BUTYL UNSUPPORTED CHEMTEK™ VITON/BUTYL		
	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate
1. Acetaldehyde	■	380	E	P	—	—	E	10	F	NR	—	—	NR	—	—	E	13	F	E	10	F	—	—	—	—	—	—
2. Acetic Acid, Glacial, 99.7%	■	150	—	G	158	—	E	390	—	NR	—	—	F	45	G	E	110	—	E	263	—	E	>480	—	DD	>480	—
3. Acetone	▲	>480	E	NR	—	—	G	10	F	P	143	G	NR	<5	—	E	10	F	G	12	G	E	>480	E	DD	93	VG
4. Acetonitrile	▲	>480	E	F	30	F	E	20	VG	■	150	G	NR	—	—	E	4	VG	E	13	VG	E	>480	E	DD	70	E
5. Acrylic Acid	—	—	—	G	120	—	E	395	—	NR	—	—	NR	—	—	E	80	—	E	67	—	—	—	—	—	—	—
6. Acrylonitrile	▲	>480	E	—	—	—	—	—	—	▲	>480	—	—	—	—	E	5	F	—	—	—	E	>480	—	E	>480	—
7. Allyl Alcohol	▲	>480	E	F	140	F	E	140	VG	P	—	—	P	60	G	E	10	VG	E	20	VG	E	>480	—	E	>180	—
8. Ammonia Gas	■	19	E	▲	>480	E	▲	>480	—	—	—	—	—	—	—	—	—	—	■	27	E	—	—	—	—	—	—
9. Ammonium Fluoride, 40%	▲	>480	E	E	>360	—	E	>480	—	NR	—	—	E	>360	—	E	>360	—	E	>360	—	—	—	—	—	—	—
10. Ammonium Hydroxide, Conc. (28-30% Ammonia)	E	30	—	E	>360	—	E	250	—	NR	—	—	E	240	—	E	90	—	E	247	—	E	>480	—	E	>480	—
11. n-Amyl Acetate	▲	470	E	E	198	G	NR	—	—	G	>360	E	P	—	—	NR	—	—	P	—	—	E	128	G	F	<10	F
12. Amyl Alcohol	▲	>480	E	E	>480	E	E	348	VG	G	180	G	G	12	E	E	25	VG	E	52	VG	E	>480	E	E	>480	E
13. Aniline	▲	>480	E	NR	—	—	E	145	F	F	>360	E	F	62	G	E	25	VG	E	82	G	E	>480	E	E	>480	E
14. Aqua Regia	—	—	—	F	>360	—	G	>480	—	NR	—	—	G	120	—	NR	—	—	G	193	—	E	>480	—	E	>480	—
15. Benzaldehyde	▲	>480	E	NR	—	—	NR	—	—	G	>360	E	NR	—	—	G	10	VG	G	27	F	E	>480	E	E	100	E
16. Benzene (Benzol)	▲	>480	E	P	—	—	NR	—	—	E	>360	E	NR	—	—	NR	—	—	NR	—	—	E	20	F	E	253	VG
17. Benzotrichloride	▲	>480	E	E	>480	E	NR	—	—	—	—	—	G	—	—	NR	—	—	NR	—	—	—	—	—	—	—	—
18. Benzotrifluoride	▲	>480	E	E	170	G	—	—	—	—	—	—	G	<10	F	P	50	G	P	—	—	—	—	—	—	—	—
19. Bromine Water	—	—	—	E	>480	E	E	>480	E	NR	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20. 1-Bromopropane (Propyl Bromide)	▲	>480	E	▼	23	F	▼	<10	P	▲	>480	E	▼	<10	F	▼	<10	P	▼	<10	P	▼	10	P	■	182	VG
21. 2-Bromopropionic Acid	▲	>480	—	F	120	—	E	460	—	—	—	—	G	180	—	E	190	—	G	190	—	—	—	—	—	—	—
22. n-Butyl Acetate	▲	>480	E	F	75	F	NR	—	—	G	>360	E	NR	—	—	NR	—	—	P	—	—	E	80	G	DD	<10	F
23. n-Butyl Alcohol	▲	>480	E	E	>360	E	E	270	E	F	75	G	G	180	VG	E	35	VG	E	75	VG	E	>480	E	E	>480	E
24. Butyl Carbitol	—	—	—	E	>323	E	G	188	F	E	>480	E	E	397	VG	E	44	G	E	148	G	—	—	—	—	—	—
25. Butyl Cellosolve	▲	>480	E	E	470	VG	E	180	G	■	120	G	P	60	G	E	45	G	E	48	G	E	>480	—	E	>480	—
26. gamma-Butyrolactone	▲	>480	E	NR	—	—	E	245	G	E	120	VG	NR	—	—	E	60	G	E	104	F	E	>480	E	E	>480	E
27. Carbon Disulfide	▲	>480	E	G	30	F	NR	—	—	E	>360	E	NR	<5	—	NR	—	—	NR	—	—	▼	7	G	■	138	E
28. Carbon Tetrachloride	—	—	—	G	150	G	NR	—	—	E	>360	E	F	25	F	NR	—	—	NR	—	—	F	53	P	—	—	—
29. Cellosolve® (Ethyl Glycol Ether, 2-Ethoxyethanol)	E	>480	E	G	293	G	E	128	G	■	75	G	P	38	G	E	25	VG	E	25	VG	E	>480	E	E	465	E
30. Cellosolve Acetate® (2-Ethoxyethyl Acetate, EGEAA)	▲	>480	E	F	90	G	G	40	F	■	>360	E	NR	—	—	E	10	G	E	23	G	E	>480	E	DD	105	VG

CHEMICAL	BARRIER			SOL-VEX			29-SERIES			PVA			SNORKEL			CANNERS AND HANDLERS*			CHEMI-PRO*			CHEMTEX BUTYL			CHEMTEX VITON/BUTYL		
31. Chlorine Gas	▲	>480	E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32. Chlorobenzene	▲	>480	E	NR	—	—	NR	—	—	E	>360	E	NR	—	—	NR	—	—	NR	—	—	P	9	P	F	>480	E
33. 4-Chlorobenzotrifluoride	—	—	—	E	320	VG	F	50	F	F	—	—	F	—	—	P	—	—	P	—	—	■	75	F	■	48	F
34. 2-Chlorobenzyl Chloride	E	120	E	—	—	—	F	200	E	E	>480	E	F	65	E	F	20	F	—	—	—	E	>480	E	E	>480	E
35. Chloroform	E	20	G	NR	—	—	NR	—	—	E	>360	E	NR	—	—	NR	—	—	NR	—	—	P	5	P	■	212	VG
36. 1-Chloronaphthalene	▲	>480	E	P	—	—	NR	—	—	G	>360	E	NR	—	—	NR	—	—	P	—	—	E	>480	E	E	>480	E
37. 2-Chlorotoluene	▲	>480	E	G	120	G	NR	—	—	—	—	—	—	—	—	NR	—	—	NR	—	—	NR	—	—	—	—	—
38. 4-Chlorotoluene	▲	>480	E	P	—	—	NR	—	—	—	—	—	P	—	—	NR	—	—	NR	—	—	▼	30	F	▲	>480	E
39. "Chromic Acid" Cleaning Solution	—	—	—	F	240	—	NR	—	—	NR	—	—	G	>360	—	NR	—	—	NR	—	—	E	>480	—	E	>480	—
40. Citric Acid, 10%	—	—	—	E	>360	—	E	>480	—	F	50	—	E	>360	E	E	>360	—	E	>480	—	—	—	—	—	—	—
41. Cyclohexane	—	—	—	▲	>360	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	G	30	F	▲	>480	—
42. Cyclohexanol	▲	>480	E	E	>360	E	E	390	VG	G	>360	E	E	360	E	E	103	VG	E	47	G	E	>480	E	▲	>480	E
43. Cyclohexanone	▲	>480	E	F	103	G	P	23	F	E	>480	E	NR	—	—	P	—	—	P	—	—	E	>480	—	▼	150	—
44. 1,5-Cyclooctadiene	▲	>480	E	E	>480	E	NR	—	—	—	—	—	NR	—	—	NR	—	—	NR	—	—	P	—	—	—	—	—
45. Diacetone Alcohol	▲	>480	E	G	240	E	E	208	VG	■	150	G	NR	—	—	E	43	VG	E	60	VG	E	>480	—	DD	—	—
46. Dibutyl Phthalate	—	—	—	G	>360	E	F	132	G	E	>360	E	NR	—	—	E	20	—	G	>480	E	—	—	—	—	—	—
47. 1,2-Dichloroethane (Ethylene Dichloride, EDC)	▲	>480	E	NR	—	—	NR	—	—	E	>360	E	NR	—	—	P	—	—	P	—	—	—	—	—	—	—	—
48. Diethylamine	▲	>480	E	F	51	F	P	—	—	NR	—	—	NR	—	—	NR	—	—	NR	—	—	F	18	—	▼	19	—
49. Diisobutyl Ketone (DIBK)	▲	>480	E	E	263	G	P	—	—	G	>360	E	P	—	—	P	—	—	P	—	—	E	231	G	DD	15	G
50. Dimethyl Sulfoxide (DMSO)	▲	>480	E	E	240	VG	E	398	G	NR	—	—	NR	—	—	E	180	E	E	150	E	E	>480	—	DD	>480	—
51. Dimethylacetamide (DMAC)	▲	>480	E	NR	—	—	NR	—	—	NR	—	—	NR	—	—	E	15	G	E	30	G	E	>480	—	DD	>480	—
52. Dimethylformamide (DMF)	▲	>480	E	NR	—	—	E	45	F	NR	—	—	NR	19	—	E	25	VG	E	40	G	E	>480	E	DD	>480	E
53. Dioctyl Phthalate (DOP, DEHP)	▲	>480	E	G	>360	E	G	>480	E	E	30	F	NR	—	—	P	—	—	E	>360	E	—	—	—	—	—	—
54. Di-n-Octyl Phthalate (DNOP)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	E	>480	—	—	—	—
55. 1,4-Dioxane	▲	>480	E	NR	—	—	NR	—	—	P	—	—	NR	—	—	F	5	F	F	18	F	E	>480	—	—	—	—
56. Electroless Copper Plating Solution	—	—	—	E	>360	—	E	>360	—	NR	—	—	E	>360	—	E	>360	—	—	—	—	—	—	—	—	—	—
57. Electroless Nickel Plating Solution	—	—	—	E	>360	—	E	>360	—	NR	—	—	E	>360	—	E	>360	—	—	—	—	—	—	—	—	—	—
58. Epichlorohydrin	▲	>480	E	NR	—	—	P	—	—	E	300	E	NR	—	—	E	5	F	E	17	VG	E	>480	—	—	—	—
59. Ethidium Bromide, 10%	▲	>480	E	▲	>480	E	—	—	—	NR	—	—	—	—	—	—	—	—	—	—	—	E	>480	—	E	>480	—
60. Ethyl Acetate	▲	>480	E	NR	—	—	F	10	P	F	>360	E	NR	—	—	G	5	F	F	10	F	E	196	G	DD	10	G
61. Ethyl Alcohol, Denatured, 92% Ethanol	▲	>480	E	E	240	VG	E	113	VG	NR	—	—	G	60	VG	E	15	VG	E	37	VG	E	>480	E	E	>480	E
62. Ethylene Glycol	▲	>480	E	E	>360	E	E	>480	E	F	120	VG	E	>360	E	E	>360	E	E	>480	E	—	—	—	—	—	—
63. Ethylene Oxide Gas	■	234	E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
64. Ethyl Ether	▲	>480	E	E	95	G	F	<10	F	G	>360	E	NR	—	—	NR	—	—	NR	—	—	—	—	—	—	—	—
65. Ethyl L-Lactate	E	>480	E	E	273	G	E	125	VG	E	125	G	E	15	G	E	15	VG	E	28	VG	E	>480	E	E	>480	E
66. Formaldehyde, 37% in 1/3 Methanol/Water	▲	>480	E	E	>360	E	E	39	VG	P	—	—	E	100	E	E	10	G	E	32	E	E	>480	—	E	>480	—
67. Formic acid, 90%	▲	>480	—	F	240	—	E	>480	—	NR	—	—	E	>360	—	E	150	—	E	>360	—	E	>480	—	—	—	—
68. Furfural	▲	>480	E	NR	—	—	E	40	P	F	>360	E	NR	—	—	E	15	VG	E	43	VG	E	>480	—	G	>480	—
69. Freon TF	—	—	—	E	>360	E	E	240	E	G	>360	E	NR	—	—	NR	—	—	NR	—	—	—	—	—	—	—	—
70. Gasoline, Unleaded (Shell Premium winter blend)	▲	170	E	E	>480	E	NR	—	—	G	>360	E	P	—	—	NR	—	—	NR	—	—	F	20	F	E	>480	E
71. Glutaraldehyde, 25%	—	—	—	E	>360	E	E	>480	E	P	<10	F	E	>360	E	E	210	VG	—	—	—	—	—	—	—	—	—
72. HCFC-141B	▲	>480	E	E	92	F	F	33	F	P	—	—	NR	—	—	NR	—	—	NR	—	—	F	40	F	F	<10	F
73. n-Heptane	▲	>480	E	—	—	—	—	—	—	▲	>480	—	NR	—	—	—	—	—	—	—	—	P	10	F	E	>480	E
74. Hexamethyldisilazine	▲	>480	E	E	>360	—	E	42	—	G	>360	—	P	—	—	F	15	F	F	43	G	■	305	G	■	>480	G
75. n-Hexane	▲	>480	E	E	>480	E	E	48	G	G	>360	E	NR	—	—	NR	—	—	P	—	—	P	5	F	E	>480	E
76. HFE 7100	▲	>480	E	E	>480	E	E	>480	E	P	—	—	E	>480	E	E	120	E	—	—	—	—	—	—	—	—	—
77. HFE 71DE	■	164	E	F	10	F	F	<10	F	F	>480	E	NR	—	—	NR	—	—	—	—	—	—	—	—	—	—	—
78. Hydrazine, 65%	—	—	—	E	>480	—	E	386	—	NR	—	—	E	>360	—	E	150	VG	E	>360	—	E	>480	—	—	—	—
79. Hydrobromic Acid, 48%	▲	>480	—	E	>360	—	E	>480	—	NR	—	—	E	>360	—	E	>360	—	E	>360	—	—	—	—	—	—	—

80. Hydrochloric Acid, 10%	—	—	—	E	>360	—	E	>480	—	NR	—	—	E	>360	—	E	>360	—	E	>360	—	—	—	—	—	—	—
81. Hydrochloric Acid, 37% (Concentrated)	▲	>480	—	E	>480	—	E	>480	—	NR	—	—	E	300	—	E	290	—	E	>360	—	—	—	—	—	—	—
82. Hydrofluoric Acid, 48%	▲	>480	—	E	334	—	■	>480	—	NR	—	—	■	155	—	▲	>480	—	—	—	—	E	>480	—	▲	>480	—
83. Hydrofluoric Acid, 95%	▲	>480	E	—	—	—	■	342	VG	—	—	—	—	—	—	—	—	—	—	—	—	▲	>480	E	—	—	—
84. Hydrogen Fluoride Gas	▲	>480	E	■	<15	P	—	—	—	—	—	—	■	2	—	■	15	F	■	<15	F	—	—	—	—	—	—
85. Hydrogen Peroxide, 30%	—	—	—	E	>360	—	E	>480	—	NR	—	—	E	>360	—	E	>360	—	G	>360	—	—	—	—	▲	>480	—
86. Hydroquinone, saturated solution	—	—	—	E	>360	E	E	108	E	NR	—	—	E	>360	E	G	>360	E	E	>360	E	—	—	—	—	—	—
87. Hypophosphorus Acid, 50%	—	—	—	E	>480	—	E	>240	—	NR	—	—	E	—	—	E	>480	—	—	—	—	—	—	—	—	—	—
88. Isobutyl Alcohol	▲	>480	E	E	>360	E	E	478	E	P	—	—	F	10	VG	E	15	VG	E	52	E	E	>480	E	E	>480	E
89. Isooctane	▲	>480	E	E	>360	E	E	268	VG	E	>360	E	P	—	—	NR	—	—	P	—	—	■	58	F	▲	>480	E
90. Isopropyl Alcohol	▲	>480	E	E	>360	E	E	110	E	NR	—	—	G	150	E	E	35	VG	E	57	E	—	—	—	—	—	—
91. Kerosene	▲	>480	E	E	>360	E	E	185	G	G	>360	E	F	>360	E	NR	—	—	P	—	—	G	82	—	E	>480	—
92. Lactic Acid, 85%	▲	>480	—	E	>360	—	E	>480	—	F	>360	—	E	>360	—	E	>360	—	E	>360	—	—	—	—	—	—	—
93. Lauric Acid, 36% in Ethanol	—	—	—	E	>360	—	E	>480	—	NR	—	—	F	15	—	E	>360	—	E	>360	—	—	—	—	—	—	—
94. d-Limonene	▲	>480	E	E	>480	E	NR	—	—	G	>480	E	G	125	G	NR	—	—	NR	—	—	F	57	F	F	>480	E
95. Maleic Acid, saturated solution	—	—	—	E	>360	—	E	>480	—	NR	—	—	G	>360	—	E	>360	—	E	>360	—	—	—	—	—	—	—
96. Mercury	—	—	—	▲	>480	E	—	—	—	—	—	—	▲	>480	E	▲	>480	E	—	—	—	—	—	—	—	—	—
97. Methyl Alcohol (Methanol)	▲	>480	E	E	103	VG	E	73	VG	NR	—	—	G	45	G	E	12	VG	E	22	E	E	>480	—	DD	363	—
98. Methylamine, 40%	▲	>480	E	E	>360	E	E	153	G	NR	—	—	E	135	VG	E	55	VG	E	100	E	E	>480	—	E	>480	—
99. Methyl Amyl Ketone (MAK)	▲	>480	E	F	53	F	F	10	F	E	>360	E	NR	—	—	F	<10	F	F	<10	F	E	155	G	DD	17	F
100. Methyl-t-Butyl Ether (MTBE)	E	>480	E	E	>360	E	P	—	—	G	>360	E	NR	—	—	NR	—	—	NR	—	—	G	38	F	—	—	—
101. Methyl Cellosolve®	■	470	F	F	208	G	E	10	F	E	30	G	P	55	G	E	20	VG	—	—	—	▲	>480	E	▲	>480	E
102. Methylene Bromide (DBM)	▲	>480	E	NR	—	—	NR	—	—	G	>360	E	NR	—	—	NR	—	—	NR	—	—	E	70	F	E	>480	E
103. Methylene Chloride (DCM)	E	20	VG	NR	—	—	NR	—	—	G	>360	E	NR	—	—	NR	—	—	NR	—	—	G	13	P	E	29	G
104. Methylene bis(4-Phenylisocyanate) (MDI)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	▲	>480	E	▲	>480	E	—	—	—	—	—	—
105. Methyl Ethyl Ketone (MEK)	▲	>480	E	NR	—	—	P	—	—	F	90	VG	NR	—	—	F	5	F	P	<10	F	E	183	G	DD	20	G
106. Methyl Ethyl Ketone (MEK)/Toluene, 1/1	▲	>480	E	—	—	—	—	—	—	—	—	—	—	—	—	F	5	F	—	—	—	F	60	—	—	—	—
107. Methyl Iodide (Iodomethane)	▲	>480	E	NR	—	—	NR	—	—	F	>360	E	NR	—	—	NR	—	—	NR	—	—	F	15	P	G	215	VG
108. Methyl Isobutyl Ketone (MIBK)	▲	>480	E	P	45	F	NR	—	—	F	>360	E	NR	—	—	P	—	—	P	—	—	E	245	G	DD	30	G
109. Methyl Methacrylate (MMA)	▲	>480	E	P	35	P	NR	—	—	G	>360	E	NR	—	—	P	—	—	NR	—	—	E	85	G	DD	10	F
110. N-Methyl-2-Pyrrolidone (NMP)	▲	>480	E	NR	—	—	NR	—	—	NR	—	—	NR	—	—	E	75	VG	F	47	VG	E	>480	—	DD	—	—
111. Mineral Spirits, Rule 66	▲	>480	E	E	>480	E	E	125	G	E	>360	E	F	150	VG	NR	—	—	G	23	G	—	—	—	—	—	—
112. Monoethanolamine	—	—	—	E	>360	E	E	400	E	E	>360	E	E	>480	E	E	50	E	E	57	E	—	—	—	■	>120	—
113. Morpholine	▲	>480	E	NR	—	—	P	—	—	G	90	G	NR	—	—	G	20	G	E	43	G	E	>480	E	DD	235	VG
114. Naphtha, VM&P	▲	>480	E	E	>360	E	G	103	G	E	420	E	F	120	VG	NR	—	—	NR	—	—	—	—	—	—	—	—
115. Nitric Acid, 10%	▲	>480	—	E	>360	—	E	>480	—	NR	—	—	G	>360	—	G	>360	—	E	>360	—	—	—	—	—	—	—
116. Nitric Acid, 70% (Concentrated)	E	>480	—	NR	—	—	▲	>480	—	NR	—	—	F	109	—	NR	—	—	NR	—	—	—	—	—	—	—	—
117. Nitric Acid, Red Fuming	▲	>480	E	NR	—	—	NR	—	—	NR	—	—	P	—	—	P	—	—	NR	—	—	—	—	—	—	—	—
118. Nitrobenzene	▲	>480	E	NR	—	—	NR	—	—	G	>360	E	NR	—	—	F	15	G	F	42	G	E	>480	—	E	>480	—
119. Nitromethane	▲	>480	E	F	30	F	E	60	G	G	>360	E	P	—	—	E	10	G	E	30	E	E	>480	E	E	249	E
120. 1-Nitropropane	■	368	E	NR	—	—	F	30	G	E	>480	G	NR	—	—	E	15	G	E	25	G	E	>480	E	DD	255	E
121. 2-Nitropropane	▲	>480	E	NR	—	—	F	25	F	E	>360	E	NR	—	—	E	5	G	E	30	VG	—	—	—	—	—	—
122. n-Octyl Alcohol	—	—	—	E	>360	E	E	218	E	G	>360	E	F	>360	E	E	30	VG	E	53	G	—	—	—	—	—	—
123. Oleic Acid	—	—	—	E	>360	E	F	13	VG	G	60	E	F	90	VG	F	>360	E	G	120	—	—	—	—	—	—	—
124. Oxalic Acid, saturated solution	—	—	—	E	>360	—	E	>480	—	P	—	—	E	>360	—	E	>360	—	E	>360	—	—	—	—	—	—	—
125. Pad Etch® 1 (Ashland Chemical)	—	—	—	E	>360	—	E	>360	—	F	34	—	E	>360	—	E	>360	—	E	>360	—	—	—	—	—	—	—
126. Palmitic Acid, saturated solution	—	—	—	G	30	—	E	>480	—	P	—	—	G	75	—	G	5	—	E	193	—	—	—	—	—	—	—
127. Pentachlorophenol, 5% in Mineral Spirits	—	—	—	E	>360	E	E	151	F	E	5	F	F	180	E	NR	—	—	—	—	—	—	—	—	—	—	—
128. n-Pentane	E	>480	E	E	>360	E	G	30	G	G	>360	E	NR	—	—	P	—	—	E	13	G	—	—	—	—	—	—

129. Perchloric Acid, 60%	—	—	—	E	>360	—	E	>480	—	NR	—	—	E	>360	—	F	>360	—	E	>360	—	—	—	—	—	—	—
130. Perchloroethylene (PERC)	▲	>480	E	G	361	VG	NR	—	—	E	>360	E	NR	—	—	NR	—	—	NR	—	—	P	<10	F	E	>480	E
131. Phenol, 90%	▲	>480	E	NR	—	—	E	353	G	F	>360	E	G	75	VG	E	90	—	E	180	E	E	>480	—	E	>480	—
132. Phosphoric Acid, 85% (Concentrated)	▲	>480	—	E	>360	—	G	>360	—	NR	—	—	G	>360	—	F	>360	—	G	>360	—	—	—	—	—	—	—
133. Potassium Hydroxide, 50%	—	—	—	E	>360	—	E	>480	—	NR	—	—	E	>360	—	E	>360	—	E	>360	—	—	—	—	—	—	—
134. Propane Gas	—	—	—	▲	>480	E	▲	>480	E	—	—	—	■	7	VG	—	—	—	—	—	—	—	—	—	—	—	—
135. n-Propyl Acetate	—	—	—	F	20	G	P	—	—	G	120	VG	NR	—	—	P	—	—	P	—	—	E	135	G	DD	<10	F
136. n-Propyl Alcohol	E	>480	E	E	>360	E	E	323	E	P	—	—	F	90	VG	E	23	VG	E	30	E	E	>480	—	E	>480	—
137. Propylene Glycol Methyl Ether Acetate (PGMEA)	▲	>480	E	E	200	F	G	37	F	E	>360	E	P	—	—	G	13	F	G	18	F	▲	>480	E	■	334	E
138. Propylene Glycol Monomethyl Ether (PGME)	—	—	—	—	—	—	P	—	—	—	—	—	P	—	—	—	—	—	—	—	—	▲	>480	E	▲	>480	E
139. Propylene Oxide	▲	>480	E	NR	—	—	NR	—	—	G	35	G	NR	—	—	P	—	—	P	—	—	■	43	F	DD	<10	F
140. Pyridine	▲	>480	E	NR	—	—	NR	—	—	G	10	F	NR	—	—	F	10	F	P	10	F	▲	465	E	DD	40	—
141. Rubber Solvent	—	—	—	E	>360	E	E	43	G	E	>360	E	NR	—	—	NR	—	—	NR	—	—	—	—	—	—	—	—
142. Silicon Etch	▲	>480	E	NR	—	—	E	>480	—	NR	—	—	F	150	—	NR	—	—	P	—	—	—	—	—	—	—	—
143. Skydrol® 500B-4	▲	>480	E	NR	—	—	NR	—	—	—	—	—	NR	—	—	NR	—	—	NR	—	—	E	>480	E	DD	>480	E
144. Sodium Hydroxide, 50%	E	>480	—	E	>360	—	E	>480	—	NR	—	—	G	>480	—	E	>360	—	E	>360	—	E	>480	—	E	>480	—
145. Stoddard Solvent	▲	>480	E	E	>360	E	E	139	G	E	>360	E	F	57	G	NR	—	—	G	10	G	—	—	—	—	—	—
146. Styrene	▲	>480	E	NR	—	—	NR	—	—	G	>360	E	NR	—	—	NR	—	—	NR	—	—	G	26	—	E	>480	—
147. Sulfur Dichloride	—	—	—	P	>480	E	NR	—	—	—	—	—	—	—	—	NR	—	—	NR	—	—	—	—	—	—	—	—
148. Sulfuric Acid, 47% (Battery Acid)	—	—	—	E	>360	—	E	>360	—	NR	—	—	G	>360	—	E	>360	—	E	>360	—	—	—	—	—	—	—
149. Sulfuric Acid, 95-98% (Concentrated)	E	>480	E	NR	—	—	F	24	—	NR	—	—	G	26	—	NR	—	—	NR	—	—	E	>480	—	E	>480	—
150. Sulfuric Acid, 120% (Oleum)	▲	>480	E	—	—	—	F	53	G	NR	—	—	▼	25	G	—	—	—	—	—	—	—	—	—	—	—	—
151. Tannic Acid, 65%	—	—	—	E	>360	—	E	>480	E	P	—	—	E	>360	—	E	>360	—	E	>360	—	—	—	—	—	—	—
152. Tetrahydrofuran (THF)	▲	>480	E	NR	—	—	NR	—	—	P	115	F	NR	—	—	NR	—	—	NR	—	—	F	13	F	DD	10	F
153. Toluene (Toluol)	▲	>480	E	F	34	F	NR	—	—	G	>1440	E	NR	—	—	NR	—	—	NR	—	—	P	20	F	E	313	—
154. Toluene Diisocyanate (TDI)	▲	>480	E	NR	—	—	NR	—	—	G	>360	E	P	—	—	G	7	G	G	65	VG	E	>480	—	E	>480	—
155. Triallylamine	▲	>480	E	▲	>480	E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
156. Trichloroethylene (TCE)	▲	>480	E	NR	—	—	NR	—	—	E	>360	E	NR	—	—	NR	—	—	NR	—	—	NR	—	—	DD	204	VG
157. Tricresyl Phosphate (TCP)	—	—	—	E	>360	E	F	253	F	G	>360	E	F	>360	E	E	45	E	E	>360	E	E	>480	—	E	>480	—
158. Triethanolamine (TEA)	—	—	—	E	>360	E	E	170	VG	G	>360	E	E	>360	E	G	>360	E	—	—	—	—	—	—	—	—	—
159. Turpentine	▲	>480	E	E	>480	E	NR	—	—	G	>360	E	P	—	—	NR	—	—	NR	—	—	■	58	—	■	>480	E
160. Vertrel® MCA	▲	>480	E	E	110	G	E	23	G	F	>360	E	G	13	F	G	<10	F	G	<10	F	■	173	VG	DD	20	G
161. Vertrel® SMT	E	10	G	P	—	—	F	<10	F	G	17	G	G	<10	F	F	<10	F	P	<10	P	▼	18	F	DD	<10	F
162. Vertrel® XE	E	105	E	E	>480	E	E	47	G	F	40	VG	G	303	E	E	17	VG	E	43	VG	E	>480	E	DD	398	E
163. Vertrel® XF	E	>480	E	E	>480	E	E	>480	E	F	387	VG	E	>480	E	E	337	VG	E	204	G	E	>480	E	DD	>480	E
164. Vertrel® XM	E	>480	E	E	>480	E	E	105	E	F	10	G	P	55	G	E	23	VG	E	30	VG	—	—	—	—	—	—
165. Vinyl Acetate	▲	>480	E	F	18	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	NR	—	—
166. Vinyl Chloride Gas	▲	>480	E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
167. Xylenes, Mixed (Xylol)	▲	>480	E	G	96	F	NR	—	—	E	>360	E	NR	—	—	NR	—	—	NR	—	—	P	27	F	E	>480	E

▲ A degradation test against this chemical was not run. However, since its breakthrough time is greater than 480 minutes, the Degradation Rating is expected to be **Good** to **Excellent**. ■ A degradation test against this chemical was not run. However, in view of degradation tests performed with similar compounds, the Degradation Rating is expected to be **Good** to **Excellent**. ▼ A degradation test against this chemical was not run. However, in view of data obtained with similar compounds, the Degradation Rating is expected to be **Fair** to **Poor**. ***CAUTION:** This product contains natural rubber latex which may cause allergic reactions in some individuals.

NOTE:

These recommendations are based on laboratory tests, and reflect the best judgement of Ansell in the light of data available at the time of preparation and in accordance with the current revision of ASTM F 739. They are intended to guide and inform qualified professionals engaged in assuring safety in the workplace. Because the conditions of ultimate use are beyond our control, and because we cannot run permeation tests in all possible work environments and across all combinations of chemicals and solutions, these recommendations are advisory only. The suitability of a product for a specific application must be determined by testing by the purchaser.

The data in this guide are subject to revision as additional knowledge and experience are gained. Test data herein reflect laboratory performance of partial gloves and not necessarily the complete unit. Anyone intending to use these recommendations should first verify that the glove selected is suitable for the intended use and meets all appropriate health standards. Upon written request, Ansell will provide a sample of material to aid you in making your own selection under your own individual safety requirements.

NEITHER THIS GUIDE NOR ANY OTHER STATEMENT MADE HEREIN BY OR ON BEHALF OF ANSELL SHOULD BE CONSTRUED AS A WARRANTY OF MERCHANTABILITY OR THAT ANY ANSELL GLOVE IS FIT FOR A PARTICULAR PURPOSE. ANSELL ASSUMES NO RESPONSIBILITY FOR THE SUITABILITY OR ADEQUACY OF AN END-USER'S SELECTION OF A PRODUCT FOR A SPECIFIC APPLICATION.

Ansell

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Hand Protection Chemical Resistance Guide

VWR™

NORTH

CHEMICAL RESISTANCE GUIDE

This Chemical Resistance Guide incorporates three types of information:

- **Degradation (D)** is a deleterious change in one or more of the glove's physical properties. The most obvious forms of degradation are the loss of the glove's strength and excessive swelling. Several published degradation lists (primarily "The General Chemical Resistance of Various Elastomers" by the Los Angeles Rubber Group, Inc.) were used to determine degradation.
- **Breakthrough time (BT)** is defined as the elapsed time between initial contact of the liquid chemical with the outside surface of the glove and the time at which the permeation rate reaches 0.1 mg/m^2 /sec. WHEN BREAKTHROUGH OCCURS, THE GLOVE IS NO LONGER PROVIDING ADEQUATE PROTECTION.
- **Permeation rate (PR)**, measured in milligrams per square meter per second (mg/m2/sec) is the measured steady state flow of the permeating chemical through the glove elastomer. Glove thickness plays an important role in resistance to permeation.

The glove styles tested for permeation were the SSG, F101, B174, CS113B, LA102G and PNLB1815. The permeation data in this guide are based on permeation tests performed in accordance with ASTM Standard F 739 under laboratory conditions by North Safety Products or independent American Industrial Hygiene Association (AIHA) accredited laboratories. Neither North Safety Products nor the independent laboratory assumes any responsibility for the suitability of an end user's selection of gloves based on this guide.

General Recommendation:
The Guide also provides a color-coded general recommendation on which gloves should be evaluated and tested first, based on data from multiple sources. (See general recommendation color key).

Technical Assistance:
Data on chemicals not listed here can be obtained by calling the North Technical Service Department at (800) 430-4110. North also offers **ezGuide™**, an interactive software program which is designed to electronically help you select the proper glove for use against specific chemicals. This "user friendly" guide walks you step-by-step through the process to determine what type of glove to wear and its permeation resistance to the selected contaminant. Product features, benefits and ordering information of the suggested products also are included in the program. **ezGuide** can be accessed from the North web site, **www.northsafety.com** or ordered by e-mailing us at **marketing@northsafety.com**.

The finest chemical handling gloves deserve to be used with the finest respiratory products. Please consult the current North Safety Products Respiratory Protection Catalog and **ezGuide™** for proper respiratory selection.

Warning:
Protective gloves and other protective apparel selection must be based on the user's assessment of the workplace hazards. Glove and Apparel materials do not provide unlimited protection against all chemicals. It is the users responsibility to determine before use that the Glove and Apparel will resist permeation and degradation by the chemicals (including chemical mixtures) in the environment of intended use.

Failure by the user to select the correct protective gloves can result in injury, sickness or death

To obtain maximum life, protective gloves and other protective apparel should have chemicals removed from the surface by washing or other appropriate methods after each use. Protective apparel should be stored away from the contaminating atmosphere.

Punctured, torn or otherwise ruptured apparel must be removed from service; unservicable apparel may be disposed of only in accordance with applicable waste disposal regulations.

Key to Degradation and Permeation Ratings

E - Excellent	Exposure has little or no effect. The glove retains its properties after extended exposure
G - Good	Exposure has minor effect with long term exposure. Short term exposure has little or no effect
F - Fair	Exposure causes moderate degradation of the glove. Glove is still useful after short term exposure but caution should be exercised with extended exposure
P - Poor	Short term exposure will result in moderate degradation to complete destruction
N/D	Permeation was not detected during the test
I/D	Insufficient data to make a recommendation

General Recommendation Color Key

Good for total immersion

Good for accidental splash protection and intermittent contact

Only use with extreme caution; Glove will fail with only short exposure

Physical Performance Chart

Physical Characteristics	Silver Shield®	Viton†	Butyl	Chemsoft®	Nitrile	Natural Rubber
Abrasion Resistance	F	G	G	E	E	E
Cut Resistance	P	G	G	E	E	E
Puncture (Snag) Resistance	P	G	G	E	E	E
Flexibility	E	G	G	E	E	E
Heat Resistance	F	G	G	G	G	G
Ozone Resistance	E	E	E	G	G	P
Tensile Strength	E	G	G	E	E	E
Low Gas Permeability	E	E	E	F	F	P

Note: Products in these categories vary in capabilities. Laboratory tests are necessary for specific recommendations.

† Viton is a Registered Trademark of DuPont Company.

		Silver Shield			Viton			Butyl			Chemsoft			Nitrile			Natural Rubber		
Chemical Name	CAS No.	D	BT	PR	D	BT	PR	D	BT	PR	D	BT	PR	D	BT	PR	D	BT	PR
Acetaldehyde	75-07-0	E	>8 hrs	N/D	P	0 min	281.9	E	>8 hrs	0.066	I/D	I/D	I/D	P	0 min	161	I/D	I/D	I/D
Acetic Acid (100%) (Glacial)	64-19-7	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	F	37 min	13.3	F	38 min	1.9	F	1.3 hrs	0.39
Acetic Aldehyde	75-07-0	E	>8 hrs	N/D	P	0 min	281.9	E	>8 hrs	0.066	I/D	I/D	I/D	P	0 min	161	I/D	I/D	I/D
Acetic Ester	141-78-6	E	>8 hrs	N/D	I/D	I/D	I/D	E	7.6 hrs	3.4	I/D	I/D	I/D	P	8 min	145	I/D	I/D	I/D
Acetone*	67-64-1	E	>8 hrs	N/D	P	2 min	383	E	>8 hrs	N/D	P	2 min	1144	P	5 min	172	P	10 min	24.3
Acetonitrile*	75-05-8	E	>8 hrs	N/D	P	15 min	28.3	E	>8 hrs	N/D	P	4 min	41.7	P	6 min	32.2	P	16 min	0.11
Acrylic Acid	79-10-7	E	>8 hrs	N/D	G	5.9 hrs	0.23	E	>8 hrs	N/D	I/D	I/D	I/D	F	I/D	I/D	G	54 min	1.6
Acrylonitrile	107-13-1	E	>8 hrs	N/D	F	14 min	28	E	>8 hrs	N/D	P	4 min	42	P	6 min	29.8	P	16 min	0.11
Ammonia (99%)	7664-41-7	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D
Ammonium Hydroxide (29%)	1336-21-6	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	F	2 hrs	0.115	F	2.2 hrs	0.05	G	60 min	28.7
Ammonium Sulfate*	7783-20-2	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8hrs	N/D	E	>8 hrs	ND	E	>8 hrs	N/D	E	>8 hrs	N/D
Aniline	62-53-3	E	>8 hrs	N/D	P	6 min	18.7	E	>8 hrs	N/D	I/D	I/D	I/D	F	1.1 hrs	45	I/D	I/D	I/D
Aniline Oil	62-53-3	E	>8 hrs	N/D	P	6 min	18.7	E	>8 hrs	N/D	I/D	I/D	I/D	F	1.1 hrs	45	I/D	I/D	I/D
Benzaldehyde	100-52-7	I/D	I/D	I/D	E	>8 hrs	4	E	>8 hrs	N/D	I/D	I/D	I/D	P	I/D	I/D	I/D	I/D	I/D
Benzene	71-43-2	E	>8 hrs	N/D	E	5.9 hrs	0.012	P	31 min	32.3	P	I/D	I/D	P	<6 min	>29	I/D	I/D	I/D
Bromoacetonitrile	590-17-0	I/D	I/D	I/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D
Bromobenzene	108-86-1	E	I/D	I/D	E	>8 hrs	N/D	P	32 min	39.8	I/D	I/D	I/D	P	13 min	9.1	I/D	I/D	I/D
1,3-Butadiene	106-99-0	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	> 8 hrs	N/D	I/D	I/D	I/D	I/D	I/D	I/D
Butyl Acetate	123-86-4	E	>8 hrs	N/D	P	I/D	I/D	G	1.8 hrs	7.61	I/D	I/D	I/D	P	29 min	54.4	F	18 min	47
Butyraldehyde	123-72-8	I/D	I/D	I/D	P	54 min	9	E	>8 hrs	N/D	I/D	I/D	I/D	P	I/D	I/D	I/D	I/D	I/D
Carbon Bisulfide	75-15-0	E	>8 hrs	N/D	E	>8 hrs	N/D	P	3 min	98.4	I/D	I/D	I/D	P	9 min	51	I/D	I/D	I/D
Carbon Disulfide	75-15-0	E	>8 hrs	N/D	E	>8 hrs	N/D	P	3 min	98.4	I/D	I/D	I/D	P	9 min	51	I/D	I/D	I/D
Carbon Tetrachloride	56-23-5	E	>8 hrs	N/D	E	>13 hrs	N/D	P	I/D	I/D	F	1.3 hrs	3.45	G	3.4 hrs	5	I/D	I/D	I/D
Caustic Soda (50%)	1310-73-2	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D
Chlorine	7782-50-5	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D
2-Chloroethanol	107-07-3	I/D	I/D	I/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D
Chloroform	67-66-3	E	>8 hrs	N/D	E	9.5 hrs	0.46	P	I/D	I/D	I/D	I/D	I/D	P	4 min	352	I/D	I/D	I/D
3-Chloroprene	107-05-1	E	>4 hrs	N/D	F	31 min	16	P	50 min	281	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D
Cyclohexane	110-82-7	E	>4hrs	N/D	E	>7 hrs	N/D	P	50 min	103.8	E	>8 hrs	N/D	G	I/D	I/D	I/D	I/D	I/D
Cyclohexanol	108-93-0	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>11 hrs	N/D	E	>6 hrs	N/D	E	>16 hrs	N/D	I/D	I/D	I/D
Cyclohexanone	108-94-1	E	>8 hrs	N/D	P	29 min	86.3	E	>16 hrs	N/D	I/D	I/D	I/D	P	I/D	I/D	F	15 min	46.9
Di(2-ethylhexyl) phthalate	117-81-7	I/D	I/D	I/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D
Dibutylphthalate	84-74-2	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>16 hrs	N/D	E	>8 hrs	N/D	E	>16 hrs	N/D	I/D	I/D	I/D
1,2-Dichloroethane	107-06-2	E	>8 hrs	N/D	E	>8 hrs	N/D	P	2.9 hrs	53	I/D	I/D	I/D	P	8 min	82.7	I/D	I/D	I/D
Dichloromethane*	75-09-2	E	>8 hrs	N/D	F	1 hr	7.3	P	8 min	116	P	1 min	>2330	P	4 min	766	P	1 min	1339

D = Degradation
BT = Breakthrough Time
PR = Permeation Rate

E = Excellent
G = Good
F = Fair
P = Poor

N/D = None Detected
I/D = Insufficient Data

Most common chemicals available through VWR.

Good for total immersion

Good for accidental splash protection and intermittent contact

Only use with extreme caution. Glove will fail with only short exposure

		Silver Shield			Viton			Butyl			Chemsoft			Nitrile			Natural Rubber		
Chemical Name	CAS No.	D	BT	PR	D	BT	PR	D	BT	PR	D	BT	PR	D	BT	PR	D	BT	PR
Diethyl Ether	60-29-7	E	>8 hrs	N/D	P	12 min	21.5	P	8 min	92.2	I/D	I/D	I/D	P	14 min	21.8	I/D	I/D	I/D
Diethyl Oxide	60-29-7	E	>8 hrs	N/D	P	12 min	21.5	P	8 min	92.2	I/D	I/D	I/D	P	14 min	21.8	I/D	I/D	I/D
Diethylamine	109-89-7	E	>8 hrs	N/D	P	35 min	852	P	47 min	46	I/D	I/D	I/D	F	I/D	I/D	I/D	I/D	I/D
Diethylaminoethanol	100-37-8	I/D	I/D	I/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>7.8 hrs	0.02	E	>8 hrs	N/D	I/D	I/D	I/D
1,4-Diethylene Dioxide	123-91-1	I/D	I/D	I/D	P	23 min	26.8	E	>20 hrs	N/D	I/D	I/D	I/D	P	28 min	77.1	I/D	I/D	I/D
Diethylene Ether	123-91-1	I/D	I/D	I/D	P	23 min	26.8	E	>20 hrs	N/D	I/D	I/D	I/D	P	28 min	77.1	I/D	I/D	I/D
Diethylene Oxide	123-91-1	I/D	I/D	I/D	P	23 min	26.8	E	>20 hrs	N/D	I/D	I/D	I/D	P	28 min	77.1	I/D	I/D	I/D
Diethylenetriamine	111-40-0	I/D	I/D	I/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D	P	I/D	I/D	I/D	I/D	I/D
Diisobutyl Ketone (80%)	108-83-8	E	>8 hrs	N/D	F	1.1 hrs	90.6	G	3.3 hrs	41.2	I/D	I/D	I/D	F	2.9 hrs	49	I/D	I/D	I/D
Dimethyl Acetamide	127-19-5	F	1.5 hrs	0.728	P	25 min	3	E	>8 hrs	N/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D
Dimethyl Formamide*	68-12-2	E	>8 hrs	N/D	P	8 min	6.5	E	>8 hrs	N/D	P	I/D	I/D	P	9 min	15	F	43 min	0.88
Dimethyl Mercury	593-74-8	E	>4 hrs	<0.017	P	<15 min	3.1	P	<15 min	46.7	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D
Dimethyl Sulfoxide	67-68-5	G	I/D	I/D	F	1.5 hrs	5	E	>8 hrs	N/D	F	41 min	3.7	F	40 min	5.2	I/D	I/D	I/D
Dimethylketone	67-64-1	E	>8 hrs	N/D	P	2 min	383	E	>8 hrs	N/D	P	1 min	42.3	P	3 min	291	P	10 min	12.2
Dioctyl Phthalate	117-81-7	I/D	I/D	I/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D
1,4-Dioxane	123-91-1	I/D	I/D	I/D	P	23 min	26.8	E	>20 hrs	N/D	I/D	I/D	I/D	P	28 min	77.1	I/D	I/D	I/D
Dioxyethylene Ether	123-91-1	I/D	I/D	I/D	P	23 min	26.8	E	>20 hrs	N/D	I/D	I/D	I/D	P	28 min	77.1	I/D	I/D	I/D
Divinyl Benzene	1321-74-0	E	>8 hrs	N/D	E	>17 hrs	N/D	F	2.2 hrs	238	I/D	I/D	I/D	P	I/D	I/D	I/D	I/D	I/D
Epichlorohydrin	106-89-8	I/D	I/D	I/D	P	2 hrs	4	E	>8 hrs	N/D	I/D	I/D	I/D	P	I/D	I/D	I/D	I/D	I/D
1,2-Epoxypropane	75-56-9	I/D	I/D	I/D	P	1 min	1790	F	2.2 hrs	7	I/D	I/D	I/D	P	<6 min	>3.9	I/D	I/D	I/D
Ethanal	75-7-0	E	>8 hrs	N/D	P	0 min	281.9	E	>8 hrs	0.066	I/D	I/D	I/D	P	0 min	161	I/D	I/D	I/D
Ethanol	64-17-5	E	>8 hrs	N/D	I/D	I/D	I/D	E	>8 hrs	N/D	F	1.2 hrs	3.3	I/D	I/D	I/D	I/D	I/D	I/D
Ether	60-29-7	E	>8 hrs	N/D	P	12 min	21.5	P	8 min	92.2	I/D	I/D	I/D	P	14 min	21.8	I/D	I/D	I/D
Ethyl Acetate*	141-78-6	E	>8 hrs	N/D	P	I/D	I/D	G	7.6 hrs	3.4	I/D	I/D	I/D	P	8 min	145	I/D	I/D	I/D
Ethyl Alcohol	64-17-5	E	>8 hrs	N/D	I/D	I/D	I/D	E	>8 hrs	N/D	F	1.2 hrs	3.3	I/D	I/D	I/D	G	31 min	2.4
Ethyl Aldehyde	75-07-0	E	>8 hrs	N/D	P	0 min	281.9	E	>8 hrs	0.066	I/D	I/D	I/D	P	0 min	161	I/D	I/D	I/D
Ethyl Ether*	60-29-7	E	>8 hrs	N/D	P	12 min	21.5	P	8 min	92.2	I/D	I/D	I/D	P	14 min	21.8	I/D	I/D	I/D
Ethylamine (70% in water)	75-04-7	F	51 min	0.65	P	I/D	I/D	E	>12 hrs	N/D	I/D	I/D	I/D	F	1.1 hrs	30.1	I/D	I/D	I/D
Ethylene Dichloride	107-06-2	E	>8 hrs	N/D	E	>8 hrs	N/D	F	2.9 hrs	53	I/D	I/D	I/D	P	8 min	82.7	I/D	I/D	I/D
Ethylene Glycol	107-21-1	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	E	>8 hrs	N/D	I/D	I/D	I/D	E	>8hrs	N/D
Ethylene Oxide	75-21-8	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D
Formaldehyde (37% in water)	50-00-0	E	>8 hrs	N/D	E	>16 hrs	N/D	E	>16 hrs	N/D	E	>8hrs	0.007	E	>21 hrs	N/D	I/D	I/D	I/D
Furfural	98-01-1	E	>8 hrs	N/D	F	3.5 hrs	14.8	E	>16 hrs	N/D	I/D	I/D	I/D	P	24 min	265	I/D	I/D	I/D
Glutaraldehyde (25%)	111-30-8	I/D	I/D	I/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D	P	I/D	I/D	E	>6 hrs	N/D
Heptane*	142-82-5	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	E	>6 hrs	N/D	I/D	I/D	I/D	I/D	I/D	I/D

Chemical Name	CAS No.	Silver Shield			Viton			Butyl			Chemsoft			Nitrile			Natural Rubber		
		D	BT	PR	D	BT	PR	D	BT	PR	D	BT	PR	D	BT	PR	D	BT	PR
Hexahydrophenol	108-93-0	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>11 hrs	N/D	E	>6 hrs	N/D	E	>16 hrs	N/D	I/D	I/D	I/D
Hexamethylene	110-82-7	E	>4hrs	N/D	E	>7 hrs	N/D	F	50 min	103.8	E	>8 hrs	N/D	F	I/D	I/D	I/D	I/D	I/D
Hexanaphthene	110-82-7	E	>4hrs	N/D	E	>7 hrs	N/D	F	50 min	103.8	E	>8 hrs	N/D	F	I/D	I/D	I/D	I/D	I/D
*Hexane**	110-54-3	E	>8 hrs	N/D	E	>8 hrs	N/D	P	I/D	I/D	E	>6 hrs	N/D	E	I/D	I/D	I/D	I/D	I/D
*Hydrochloric Acid (37%)**	7647-01-0	E	>8 hrs	N/D	E	I/D	I/D	E	I/D	I/D	E	>6 hrs	N/D	E	>6 hrs	N/D	E	>6 hrs	N/D
Hydrofluoric Acid (48%)	7664-39-3	E	>8 hrs	0.013	G	I/D	I/D	F	I/D	I/D	I/D	I/D	I/D	G	1 hr	0.49	E	7 hrs	0.18
Iodomethane	74-88-4	P	4 min	0.026	E	6.3 hrs	0.7	F	55 min	82	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D
Isobutyl Alcohol	78-83-1	E	I/D	I/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D
*Isopropyl Alcohol**	67-63-0	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	E	>6 hrs	N/D	E	>6 hrs	N/D	G	1.7 hrs	0.42
Ketohexamethylene	108-94-1	E	>8 hrs	N/D	P	29 min	86.3	E	>16 hrs	N/D	I/D	I/D	I/D	P	I/D	I/D	F	2.1 hrs	0.07
Methacrylic Acid	79-41-4	I/D	I/D	I/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D	F	1.7 hrs	23	I/D	I/D	I/D
Methacrylonitrile	126-98-7	E	I/D	I/D	F	4 min	462	E	>8 hrs	N/D	I/D	I/D	I/D	P	7 min	560	I/D	I/D	I/D
*Methanol**	67-56-1	E	6 hrs	0.02	F	3 hrs	1	E	>8 hrs	N/D	I/D	I/D	I/D	F	32 min	11.8	F	19 min	1.97
Methenyl Trichloride	67-66-3	E	>8 hrs	N/D	E	9.5 hrs	0.46	I/D	I/D	I/D	I/D	I/D	I/D	P	4 min	352	I/D	I/D	I/D
Methyl Alcohol	67-56-1	E	6 hrs	0.02	F	3 hrs	1	E	>8 hrs	N/D	I/D	I/D	I/D	F	32 min	11.8	F	19 min	1.97
1-Methyl-4-tert-butylbenzene	98-51-1	E	>8 hrs	N/D	E	>8 hrs	N/D	F	1.78 hrs	8	I/D	I/D	I/D	P	I/D	I/D	I/D	I/D	I/D
Methyl Cellosolve	109-86-4	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	F	55 min	13.2	F	45 min	0.56
Methyl Chloride	74-87-3	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	0.0013	I/D	I/D	I/D	I/D	I/D	I/D
Methyl Chloroform	71-55-6	E	>8 hrs	N/D	E	>15 hrs	N/D	P	I/D	I/D	I/D	I/D	I/D	P	37 min	76.4	I/D	I/D	I/D
Methyl Iodide	74-88-4	P	4 min	0.026	E	6.3 hrs	0.7	F	55 min	82	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D
Methylamine (40% in water)	74-89-5	F	46 min	1.28	E	>16 hrs	N/D	E	>15 hrs	N/D	F	1.7 hr	7	E	>8 hrs	N/D	I/D	I/D	I/D
Methylbenzene	108-88-3	E	>8 hrs	N/D	E	>16 hrs	N/D	P	6 min	511	I/D	I/D	I/D	P	11 min	68.1	P	3 min	82.2
*Methylene Chloride**	75-09-2	E	>8 hrs	N/D	F	1 hr	7.32	P	I/D	I/D	P	I/D	I/D	P	4 min	766	I/D	I/D	I/D
Monoethanolamine	141-43-5	I/D	I/D	I/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D	I/D	I/D	I/D
Morpholine	110-91-8	E	>8 hrs	N/D	G	1.9 hrs	97	E	>16 hrs	N/D	I/D	I/D	I/D	P	48 min	206	I/D	I/D	I/D
Naphtha	8052-41-3	E	>8 hrs	N/D	I/D	I/D	I/D	I/D	I/D	I/D	E	>8 hrs	N/D	E	>6 hrs	N/D	I/D	I/D	I/D
n-Hexane	110-54-3	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D	E	>6 hrs	N/D	I/D	I/D	I/D	I/D	I/D	I/D
*Nitric Acid, 10%**	7697-37-3	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	> 8 hrs	N/D	E	> 8 hrs	N/D	E	>8 hrs	N/D
*Nitric Acid, 70%**	7697-37-2	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	P	23 min	NR	P	12 min	NR	P	>8 hrs	N/D
Nitrobenzene	98-95-3	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D	F	29 min	1.7	P	7 min	8.4
Nitromethane	75-52-5	I/D	I/D	I/D	I/D	I/D	I/D	E	>8 hrs	N/D	I/D	I/D	I/D	I/D	I/D	I/D	P	7 min	2.83
1-Nitropropane	108-03-2	E	>8 hrs	N/D	P	17 min	26.1	E	>8 hrs	N/D	I/D	I/D	I/D	P	12 min	29.5	I/D	I/D	I/D
n-Methyl-2-Pyrrolidone	872-50-4	I/D	I/D	I/D	I/D	I/D	I/D	E	8 hrs	N/D	I/D	I/D	I/D	F	1.45 hrs	0.388	F	1.26 hrs	3.14
n-Propyl Acetate	109-60-4	E	>8 hrs	N/D	I/D	I/D	I/D	F	2.7 hrs	2.86	I/D	I/D	I/D	P	17 min	72.5	I/D	I/D	I/D
Oxalic Acid	144-62-7	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D	G	I/D	I/D	I/D	I/D	I/D/

D = Degradation
BT = Breakthrough Time
PR = Permeation Rate

E = Excellent
G = Good
F = Fair
P = Poor

N/D = None Detected
I/D = Insufficient Data

Most common chemicals available through VWR.

Good for total immersion

Good for accidental splash protection and intermittent contact

Only use with extreme caution. Glove will fail with only short exposure

		Silver Shield			Viton			Butyl			Chemsoft			Nitrile			Natural Rubber		
Chemical Name	CAS No.	D	BT	PR	D	BT	PR	D	BT	PR	D	BT	PR	D	BT	PR	D	BT	PR
p-Dioxane	123-91-1	I/D	I/D	I/D	P	23 min	26.8	E	>20 hrs	N/D	I/D	I/D	I/D	P	28 min	77.1	I/D	I/D	I/D
Perchloric Acid (70%)	7601-90-3	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D
Perchloroethylene	127-18-4	E	>8 hrs	N/D	E	>17 hrs	N/D	P	I/D	I/D	F	1 hr	3.8	F	1.3 hrs	5.5	I/D	I/D	I/D
Perchloromethane	56-23-5	E	>8 hrs	N/D	E	>13 hrs	N/D	I/D	I/D	I/D	F	1.3 hrs	3.45	F	3.4 hrs	5	I/D	I/D	I/D
Phenol (85% in water)	108-95-2	E	>8 hrs	N/D	E	>15 hrs	N/D	E	>20 hrs	N/D	I/D	I/D	I/D	P	39 min	>1500	F	2.2 hrs	4.64
Phenylamine	62-53-3	E	>8 hrs	N/D	P	6 min	18.7	E	>8 hrs	N/D	I/D	I/D	I/D	F	1.1 hrs	45	I/D	I/D	I/D
Phosphoric Acid (85%)	7664-38-2	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D
Pimelic Ketone	108-94-1	E	>8 hrs	N/D	P	29 min	86.3	E	>16 hrs	N/D	I/D	I/D	I/D	I/D	I/D	I/D	F	2.1 hrs	0.07
2-Propanone	67-64-1	E	>8 hrs	N/D	P	2 min	383	E	>8 hrs	N/D	P	1 min	42.3	P	3 min	291	P	10 min	12.2
Propyl Acetate	109-60-4	E	>8 hrs	N/D	P	I/D	I/D	G	2.7 hrs	2.86	I/D	I/D	I/D	P	17 min	72.5	I/D	I/D	I/D
Propyl Alcohol	71-23-8	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	G	3.8 hrs	0.35	E	4.4 hrs	1.1	I/D	I/D	I/D
Propylene Oxide	75-56-9	I/D	I/D	I/D	P	1 min	1790	F	2.2 hrs	7	I/D	I/D	I/D	P	<6 min	>3.9	I/D	I/D	I/D
p-tert-Butyltoluene	98-51-1	E	>8 hrs	N/D	E	>8 hrs	N/D	F	1.78 hrs	8	I/D	I/D	I/D	P	I/D	I/D	I/D	I/D	I/D
Pyridine	110-86-1	I/D	I/D	I/D	P	38 min	74	E	>8 hrs	N/D	I/D	I/D	I/D	P	I/D	I/D	I/D	I/D	I/D
*Sodium Hydroxide 50%**	1310-73-2	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D
*Sodium Sulfate**	7757-82-6	E	>8 hrs	N/D	E	>8 hrs	N/D	E	> 8hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D
Styrene	100-42-5	E	>6 hrs	N/D	E	>6 hrs	N/D	F	35 Mins	0.19	P	16 min	39	P	11 min	>3.35	I/D	I/D	I/D
Sulfuric Acid (50%)	7664-93-9	E	>6 hrs	N/D	E	I/D	I/D	E	I/D	I/D	G	>8 hrs	N/D	G	>6 hrs	N/D	G	>6 hrs	N/D
Sulfuric Acid (93%)	7664-93-9	E	>8 hrs	N/D	E	>8 hrs	N/D	E	>8 hrs	N/D	P	2 min	N/D	F	1.9 hrs	11.4	G	5.1 hrs	N/D
Tetrachloroethylene	127-18-4	E	>8 hrs	N/D	E	>17 hrs	N/D	P	I/D	I/D	F	1 hr	3.8	F	1.3 hrs	5.5	I/D	I/D	I/D
Tetrachloromethane	56-23-5	E	>8 hrs	N/D	E	>13 hrs	N/D	I/D	I/D	I/D	F	1.3 hrs	3.45	F	3.4 hrs	5	I/D	I/D	I/D
*Tetrahydrofuran**	109-99-9	E	>8 hrs	N/D	P	0 min	327	F	27 min	112	P	I/D	I/D	P	0 min	167	P	5 min	360
Thioglycolic Acid	68-11-1	I/D	I/D	I/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D	I/D
Toluene	108-88-3	E	>8 hrs	N/D	E	>16 hrs	N/D	P	6 min	511	P	I/D	I/D	P	11 min	68.1	P	3 min	82.2
Toluene Diisocyanate	584-84-9	E	>8 hrs	N/D	I/D	I/D	I/D	E	I/D	I/D	F	1 hr	2.52	G	I/D	I/D	I/D	I/D	I/D
1,1,1-Trichloroethane	71-55-6	E	>8 hrs	N/D	E	>15 hrs	N/D	P	I/D	I/D	I/D	I/D	I/D	F	37 min	76.4	I/D	I/D	I/D
Trichloroethylene	79-01-6	E	>8 hrs	N/D	E	7.4 hrs	0.24	P	14 min	550	I/D	I/D	I/D	P	4 min	283	P	<5 min	894
Trichloromethane	67-66-3	E	>8 hrs	N/D	E	9.5 hrs	0.46	I/D	I/D	I/D	I/D	I/D	I/D	P	4 min	352	I/D	I/D	I/D
Triethanolamine	102-71-6	I/D	I/D	I/D	I/D	I/D	I/D	E	>8 hrs	N/D	E	>8 hrs	N/D	I/D	I/D	I/D	E	>8 hrs	N/D
Triethylamine	121-44-8	I/D	I/D	I/D	E	>8 hrs	N/D	P	I/D	I/D	E	5.8 hrs	0.18	E	>8 hrs	N/D	I/D	I/D	I/D
Vinegar Naphtha	141-78-6	E	>8 hrs	N/D	P	I/D	I/D	E	7.6 hrs	3.4	I/D	I/D	I/D	P	8 min	145	I/D	I/D	I/D
Vinylstyrene	1321-74-0	E	>8 hrs	N/D	E	>17 hrs	N/D	F	2.2 hrs	238	I/D	I/D	I/D	P	I/D	I/D	I/D	I/D	I/D
Xylene	1330-20-7	E	>8 hrs	N/D	E	>8 hrs	N/D	P	I/D	I/D	P	I/D	I/D	P	21 min	18.5	I/D	I/D	I/D

D = Degradation
BT = Breakthrough Time
PR = Permeation Rate

E = Excellent
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F = Fair
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N/D = None Detected
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Good for total immersion

Good for accidental splash protection and intermittent contact

Only use with extreme caution. Glove will fail with only short exposure

Most common chemicals available through VWR.

Viton® - Unsupported Gloves

Excellent chemical resistance to chlorinated and aromatic solvents. Can be used in water based solvents without dissolving. Superior resistance to PCBs. Curved finger and hand design provides better fit for greater worker comfort.

Viton® is a registered trademark of the DuPont company.

Part No.	Description	Size	Grip/Cuff	Length/Gauge	Packaged
32887-980	Black, sanitized interior	9	Smooth/straight	11"/10 mil	1 pair
32887-990	Black, sanitized interior	9	Smooth/straight	14"/12 mil	1 pair

The Viton glove is available in sizes 8-11. Please contact VWR or refer to vwr.com for ordering information.

Silver Shield®/4H® Gloves

Resistant to over 280 different chemicals: alcohols, aliphatic, aromatics, chlorines, ketones, esters. Low cost, disposable gloves do not have to be recycled and can be readily available to workers. Does not contain chemical accelerators that can cause allergic reactions. Can be used as a secondary inner glove. Allows worker maximum protection in heavy-duty jobs where the dangers of mechanical damage to gloves are high.

Part No.	Description	Size	Grip/Cuff	Length/Gauge	Inner Pack	Case Pack
11000-646	Silver, unlined	9	Smooth/straight	14.5"/2.7 mil	10 pair	50 pair

The Silver Shield glove is available in sizes 7-11. Please contact VWR or refer to vwr.com for ordering information.

NitriGuard Unsupported Nitrile Gloves

100% nitrile content offers superior resistance to cuts, snags, abrasions and punctures. Gloves are free of latex proteins which can cause allergic reactions. Comply with USDA and FDA regulations, 21 CFR, for use in food processing. Available with unlined or flocked interior.

Part No.	Description	Size	Grip/Cuff	Length/Gauge	Inner Pack	Case Pack
32888-244	Green, sanitized interior	9	Sandpatch/straight	13"/11 mil	1 dz pair	12 dz pair
89022-080	Green, sanitized interior	9	Sandpatch/straight	13"/15 mil	1 dz pair	12 dz pair
89022-090	Green, sanitized interior	9	Sandpatch/straight	15"/22 mil	1 dz pair	6 dz pair
32888-254	Blue, sanitized interior	9	Sandpatch/straight	13"/11 mil	1 dz pair	12 dz pair
32888-274	Green, flock interior	9	Sandpatch/straight	13"/15 mil	1 dz pair	12 dz pair
32888-284	Green, flock interior	9	Sandpatch/straight	13"/17 mil	1 dz pair	12 dz pair
32888-264	Blue, flock interior	9	Sandpatch/straight	13"/15 mil	1 dz pair	12 dz pair

The NitriGuard Unsupported Nitrile glove is available in sizes 7-11. Please contact VWR or refer to vwr.com for ordering information.

Butyl - Unsupported Gloves

Highest permeation resistance to gas and water vapor for greater worker protection, especially when handling toxic substances. Flexible and sensitive, even at lower temperatures. Curved finger and hand design provides a better fit for greater worker comfort. Available with "Grip-Saf" palm for wet applications.

Part No.	Description	Size	Grip/Cuff	Length/Gauge	Packaged
32887-922	Black, sanitized interior	9	Smooth/rolled bead	11"/13 mil	1 pair
32887-912	Black, sanitized interior	9	Rough Grip-Saf/rolled bead	11"/13 mil	1 pair
32887-935	Black, sanitized interior	9	Smooth/rolled bead	11"/16 mil	1 pair
32887-932	Black, sanitized interior	9	Rough Grip-Saf/rolled bead	11"/16 mil	1 pair
The above Butyl gloves are available in sizes 7-11. Please contact VWR or refer to vwr.com for ordering information.					
32887-949	Black, sanitized interior	9	Smooth/rolled bead	14"/17 mil	1 pair
32887-944	Black, sanitized interior	9	Rough Grip-Saf/rolled bead	14"/17 mil	1 pair
The above Butyl gloves are available in sizes 8-11. Please contact VWR or refer to vwr.com for ordering information.					
32887-972	Black, sanitized interior	9	Smooth/rolled bead	14"/32 mil	1 pair
The above Butyl glove is available in sizes 9-11. Please contact VWR or refer to vwr.com for ordering information.					
32887-958	Black, sanitized interior	9	Rough Grip-Saf/rolled bead	14"/32 mil	1 pair
The above Butyl glove is available in sizes 8-11. Please contact VWR or refer to vwr.com for ordering information.					

Chemsoft® Industrial Glove

Unique patented 100% nitrile formulation is 59% stretchier[1] than the leading industrial weight nitrile gloves. Gives wearer dexterity required to pick up small parts, better than comparable nitrile gloves on the market, without hand fatigue. Comply with USDA and FDA regulations, 21 CFR, for use in food processing. Free of latex proteins which can cause allergic reactions.

[1] Based on an independent scientific comparison between the new North Chemsoft Industrial glove and Ansell-Edmont Sol-Vex brand conducted by the Akron Rubber Development Laboratory.

Part No.	Description	Size	Grip/Cuff	Length/Gauge	Packaged
15001-726	Blue, sanitized interior	9	Sandpatch/straight	13"/11 mil	1 pair
15001-736	Black, flock interior	9	Sandpatch/straight	13"/15 mil	1 pair

The Chemsoft glove is available in sizes 7-11. Please contact VWR or refer to vwr.com for ordering information.

Unsupported Premium Natural Rubber*

100% high natural rubber has excellent dexterity, elasticity, and tensile strength for long wear and comfort. Embossed palm and fingers have a better wet grip. Rolled edge prevents cuff from tearing. Chlorinated for more comfort and ease when using. Complies with USDA and FDA regulations, 21 CFR for use in food processing.

** CAUTION: This product contains natural rubber latex proteins which may cause allergic reactions.*

Part No.	Description	Size	Grip/Cuff	Length/Gauge	Inner Pack	Case Pack
32888-304	Orange, sanitized interior	9	Diamond embossed/bead	15"/18 mil	1 dz pair	12 dz pair

The Natural Rubber glove is available in sizes 7-11. Please contact VWR or refer to vwr.com for ordering information.

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We Protect Hands

[redacted]

After looking over independent studies/tests, reviewing past customers experiences/history, Guardian Manufacturing feels confident that a 7mil butyl glove would offer great dexterity for the customer, as well as superior chemical protection. See below for a screen shot of test results from an independent lab.

R = reusable S = single use	Material	Breakthrough time of neat NMP (min)	Thickness (mm)
R	Butyl rubber	480	0.7
R	Butyl rubber	480	0.3

You will notice that both of these gloves have fantastic hold out and actually both maxed out the test at 8 hours. Both of these gloves vary in thickness yet the butyl held out the NMP. We have no reason to believe a Guardian 7mil butyl glove would preform any differently.

Sincerely,

[redacted]

_____ Date: 11/30/2017

[redacted] Quality Assurance Manager

Attachment B

Examples of PPE Training Materials

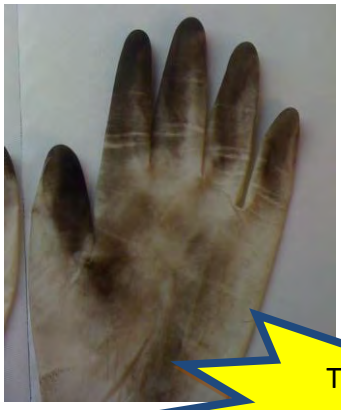
Glove Practices

Summary

Activities that require New gloves or Changing of gloves:

- *Beginning work on components, parts or tooling*
- *Returning to workstation after Flex Break, break and lunch*
- *After redressing welder electrodes*
- *Before touching unalike product, component or subassembly*
- *If gloves come in contact with a contaminated or potentially contaminated surface*
  - *Floor*
  - *Doors*
  - *Personal items*
  - *Any unclean surface*
- *After **ANY** contact with skin or hair*
- *If gloves are torn*
- *As necessary to maintain cleanliness*

VS.



Personal Protective Equipment

Personal Protective Equipment

- PPE must meet requirement of OSHA standards
- Provided by the company to protect team members from potential workplace hazards when necessary
- PPE creates barrier between hazard and route of entry
- Use of PPE does not eliminate the hazard so if the equipment fails then exposure occurs
- Must be worn to provide protection

Personal Protective Equipment

- Company provided PPE
  - The company will provide all standard PPE
  - Custom fitted PPE such as; prescription safety glasses and safety toed shoes will be subsidized for [redacted] full time team members whose jobs frequently require their use
  - [redacted] team members whose job only occasionally requires safety glasses or Contract team members that wear prescription (Rx) lenses can use non-prescription eye protection worn over prescription lenses as long as it does not comprise the fit of either piece of eyewear.
- Signage
  - Informational signage will be provided to designate PPE required in the area. This may also be called out in the Work Instructions for various manufacturing processes

[redacted]

[redacted]

[redacted]

Footwear

- <u>Safety Toed Shoes or equivalent slip-on protection required in all plant areas</u>

- Safety Toed Shoes
  - ASTM approved
  - Some areas require EH and/or ESD protection
  - No fabric allowed in production areas where exposure to chemicals can occur
  - Not required in non-production office areas

Eye Protection

- Safety Glasses are Required in the Plant
  - All eye protection must be ANSI Z87 approved
  - Must have enhanced coverage
  - Prescription safety glasses, ANSI approved
  - Splash Goggles where job exposes the team member to the risk of splashing hazardous chemicals into the eyes
  - Keep lenses clean
  - Pitted or Scratched lenses can be a source of reduced vision. Replacements; in the back of MRO
  - Use [redacted] badge to obtain replacement
  - Tinted lenses are not permitted for inside use unless the process requires tinted glasses. The EHS Manager is responsible to approve any exceptions for tinted lenses
  - PAPR Headcovers and Full Face Respirators provide face and eye protection as well as respiratory protection

[redacted]

[redacted]

[redacted]

Face – Eye Protection

- Face-shields
  - Required when exposed to over-spray, chemical splash, chipping, grinding, & abrading
  - Safety glasses with enhanced protection must be worn under the face-shield
  - Splash goggles and face-shield for chemical use
  - Impact goggles for impact use

Respirators

- [redacted] has a respiratory protection program. If your job requires a respirator you will be given a medical evaluation and special training for this program
- Fit test and maintained
- Must Meet or exceed atmospheric hazard
- Assigned Protection Factor (APF) of 1000 required in Powder Prep and Mixing
- Task specific as required
- Respirators shall be worn when the job requires them
- [redacted] will support the voluntary use of respirators if employees want extra protection in areas not requiring respirator use.
- The EHS Manager will review your situation before issuing a respirator including disposables

Hand Protection - Gloves

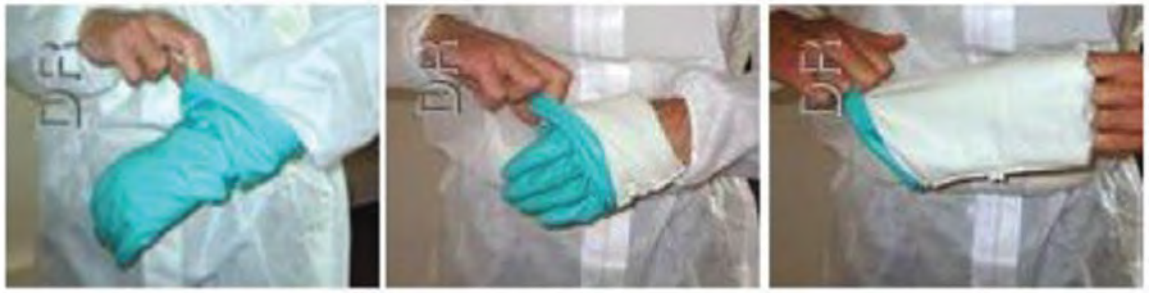
- Burns, cuts, electrical shock, amputation and absorption of chemicals are examples of hazards associated with arm and hand injuries
- Gloves are to be worn when your hands are exposed to hazards that may cause injuries.
  - Typical hazards that may require protection
    - Hazardous chemicals
    - Hot materials
    - Items that may cause cuts, abrasions or slivers
- Your supervisor or manager will provide you with the correct glove
- Inspect gloves before every use, DO NOT use worn-out, damaged gloves
- Some tasks may require double gloving for adequate protection

Abrasion Resistant

Chemical Resistant

Personal Protective Equipment

- If a glove becomes contaminated, remove it as shown



- Degradation in one or more physical properties

- Permeation or Break Through can happen even if it appears unchanged to the human eye

Personal Protective Equipment

Typical Chemical Resistant Gloves

Single use neoprene are used in all dry room areas other than powder prep, mixing & coating. Also used through remaining manufacturing process outside the dry room as needed to prevent incident exposure.

Used in areas where incidental exposure of NMP may occur. Break through after contact is approx. 2 minutes. Double gloving is required in mixing and powder prep to allow for removal of other PPE without cross contamination

13mil Butyl gloves are reusable and are used for cleaning with NMP or cleaning of filling machines. Disposable inner glove should be worn. Provides greater abrasion resistance

Personal Protective Equipment

- **Inspecting Glove for Small Leaks**
  - Hold the glove downward and grasp the cuff
  - Twirl the glove upward toward your body to trap the air inside the glove
  - Squeeze the rolled cuff into a U shape with the right hand to keep trapped air inside. Squeeze with the other hand and look for damage exposed by inflation.
  - Hold inflated glove close to your face and ear, squeezing the glove, to feel and listen for air escaping from holes.

Personal Protective Equipment

- **Protective Clothing**
  - Specialized protective clothing is available for protection not provided by the previously discussed PPE
  - Your manager or supervisor will provide the specialize PPE if your job requires the extra protection
    - Disposable Coveralls – Overall protection in a dusty, dirty environment or where chemical splash is a concern
    - Arm sleeves – Protect arms from chemical contamination
    - Aprons – Protect frontal areas from chemical splashes
    - Lab Coats – Worn in most manufacturing areas where chemical exposure is unlikely
  - Single use protective clothing must not be reused
    - For example; disposable coveralls, shoe covers and arm sleeves

Personal Protective Equipment

Aprons and tyvek suits

Aprons and tyvek suits are used to protect your skin and clothing from contamination.

How to properly don a tyvek suit:

- Unfasten ties / unzip zipper
- Scrunch up the legs of the suit, making a space for your feet to go through to touch the ground
- Step into the suit one leg at a time
- Gently pull the suit over your legs and to your waist
- One arm at a time, put on the upper portion of the suit
- Zip the zipper

How to properly doff a tyvek suit:

- Unfasten ties / unzip zipper
- Peel gown away from neck and shoulder
- Turn contaminated outside toward the inside
- Fold or roll into a bundle
- Discard

Engineering Control - Mixing Air Shower

- **Mixing Air Shower**
  - Remove outer set of gloves prior to entering air shower from mixing
  - Once air shower starts slowly turn with your arms raised for maximum effectiveness
  - When cycle finishes exit air shower to remove remaining PPE using clean set of inner gloves

Personal Protective Equipment

- Unless great care is taken in the removal and disposal of single-use protective garments, there is a risk of cross contamination from the surface of the garment to the wearer's skin or hair or to other employees and family. The protective suit should be removed in a contamination-free space. Before taking off the protective clothing, it is advisable to clean the gloves and boots in order to prevent dust being thrown up. Mixing team members exit through the air shower to remove particles on outside of disposable coverall.

- Any protective items removed, such as adhesive tape, should be immediately disposed of in a waste container provided for this purpose. With the protective gloves still on, the wearer should begin rolling the hood back, taking care not to let the outside of the coverall touch any clothing or uncovered area of the body.

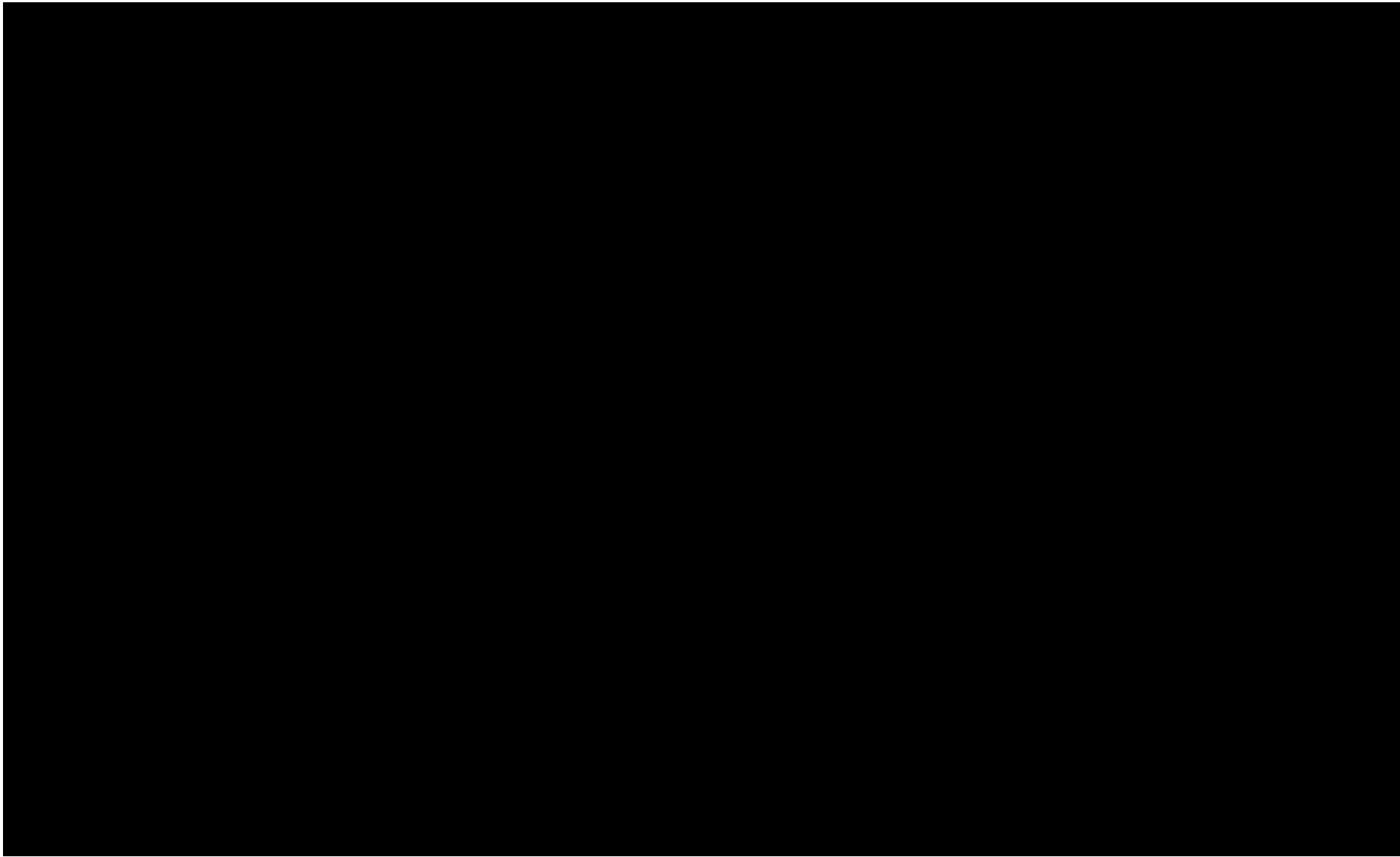
Personal Protective Equipment

- Unzip the coverall and begin rolling it outwards, rolling it down over your shoulders. Place both hands behind your back and pull down each arm until completely removed. Sit down and roll the coveralls down (ensuring the contaminated side is not touched or comes into contact with clothing) over your knees until completely removed. Finally discard the suit in the trash can and remove your gloves.

- The process of removing the suit results in contamination of the workplace, so this area must be cleaned as well. Leaving the danger zone while still contaminated poses a risk not only to the wearer of the protective suit, but also to others who are not involved in the procedure.

https://youtu.be/4G2KqFminnc

Questions?



TITLE: Dress Code & PPE Policy

ATTACHMENTS: [redacted] Glove Practices Summary

REV	ECO NO.	DESCRIPTION OF CHANGE	ORIGINATOR	DATE
A	**30**	Production Release	[redacted]	29 MAY 07
B	**20177**	24 month review. Small change to jewelry requirements	[redacted]	19 OCT 12
C	**20416**	Add 6.1.7.1, reference to [redacted] glove practices document	[redacted]	17 Jan 13
D	**CR 22189**	Safety Documentation Updates	[redacted]	See CR
E	**CR-34495**	Updates to address dress code and use of saftey glasses for both associates and visitors.	[redacted]	30 Nov 17

1.0 PURPOSE

The purpose of this document is to document the required personal protective equipment (PPE) and dress code requirements when walking or working in non-office areas.

2.0 SCOPE

This work instruction applies to all work areas where [redacted] Associates may be exposed or come in contact with chemicals, batteries, flying objects, heavy lifting, equipment or objects that are in motion, or any other area where an injury can result if an associate is not protected. Areas and rooms affected by this procedure are called Affected Areas and include, but are not limited to; manufacturing, manufacturing support, test rooms, R&D laboratories, waste rooms, facilities and maintenance work areas.

3.0 DEFINITIONS

3.1 Personal Protective Equipment (PPE) – Any clothing or other item designed to create a barrier against workplace hazards. Examples include, but are not limited to, safety glasses, gloves, shoes, harnesses, hard hats, and hearing protectors.

3.2 Affected Areas – An area where the General Dress Code requirements exist. Affected areas include, but are not limited to,

- **3.2.1** Manufacturing
- **3.2.2** Testing or Engineering Development
- **3.2.3** Research and Development (R&D)
- **3.2.4** Facilities work areas
- **3.2.5** Maintenance work areas
- **3.2.6** Mechanical rooms
- **3.2.7** Destructive Analysis

NOTE: Affected areas do not include offices, cubicles, hallways in office/cubicle areas, meeting rooms, cafeterias or break areas.

4.0 REFERENCES

4.1 OSHA Regulation 29 CFR 1910 pertaining to PPE

5.0 RESPONSIBILITIES

5.1 Environmental Health, Safety, & Security (EHSS) is responsible for:

- **5.1.1** Reviewing and updating this procedure as necessary to maintain compliance with the Personal Protective Equipment regulation.
- **5.1.2** Performing hazard assessments and PPE reviews as needed.
- **5.1.3** Training associates on PPE as needed.
- **5.1.4** Maintaining records resulting from this procedure.

5.2 All Associates affected by this procedure are responsible for following this procedure when required or necessary to protect themselves from hazards.

5.3 All Associates managing temporary associates, interns, co-ops, contractors, visitors, or other guest to an [redacted] building are responsible for informing

them of this procedure and ensuring that they are complying with this procedure.

5.4 Associates purchasing or modifying workstations, equipment, or machines, as well as modifying or constructing an [redacted] building, where hazards may be present are required to hold a hazard assessment review with EHSS to ensure that the PPE requirements in this procedure have been implemented and are adequate.

5.5 Management is responsible for

5.5.1 Identifying any additional work areas, equipment, or machines that may become subject to this procedure and notifying EHSS before the change occurs.

5.5.2 Assuring that all associates, temporary associates, interns, co-ops, contractors, visitors, or other guests requiring training attend or receive the training per this procedure.

5.5.3 Assuring that all associates, temporary associates, interns, co-ops, contractors, visitors, or other guests are following this procedure as required.

5.5.4 Addressing all violations of this procedure at the time a violation is brought to their attention.

6.0 Procedure

6.1 General Dress Code – the following dress code must be followed by all [redacted] associates, temporary associates, interns, co-ops, contractors, visitors, or other guest to the [redacted] facility that enters an Affected Area:

6.1.1 Pants with full leg coverage to the ankle while standing. (Skirts, shorts, and capris are not permitted). Holes in pants where skin can be seen, regardless of size, are not allowed.

6.1.2 Shirts with full coverage to the shoulder, as well as full coverage of the midriff, stomach. . (Loose fitting clothing that may get caught in machinery and equipment is not permitted. Tube tops, tank tops, tops with spaghetti straps, or tops without a moderate neck line are not permitted). All shirts must be work appropriate.

6.1.3 Shoes less than a 1.5 inch heel and full toe coverage (Sandals, shoes with no back, shoes with holes or designed openings are not permitted..).

6.1.4 Clothing may not contain offensive language or graphics.

6.1.5 Long hair, touching the shoulders or longer, must be pulled back so that it is always behind the face and/or shoulders. Pulled back hair may not come in front of shoulders when associate is bending over or looking down. Hair must be pulled back using cloth pony tail holders, plastic headbands, plastic barrettes, or non-metal holders. (Hats are not permitted).

6.1.6 Beards below the shoulder length should either be rolled or tied up, or should be covered with a beard cover. See supervisor or safety for beard covers.

6.1.7 No jewelry may be worn on the hands, arms or neck. No bracelets, watches, rings, necklaces, or pins may be worn. Any style earring that extends past the earlobe may not be worn. Ear gauges must be a solid "plug" style (no hoop style gauges). Any other facial piercings including but not limited to: eyebrow, nose, lip and ear should be fitted with the lowest profile insert available, such as studs and bars while avoiding hoop or crescent style inserts. "Stud jewelry, "Dermals" are allowed as long as they are not on the hands and do not pose a safety hazard.

6.1.8 Gloves & finger cots as designated in the safety section of the work station or area's work instructions. Gloves may not be cut, sliced, or modified from its original condition.

6.1.8.1 See [redacted] for guidelines on glove change practices.

6.1.9 Lab coats must be worn and fully fastened or snapped. Lab coat sleeves should always be pulled down to their full wrist length when on the production floor. Hoods should not be visible, and should be tucked into the lab coat.

6.1.10 Safety glasses must be worn and be stamped with the ANSI Z87 stamp. Prescription safety glasses must have the side shields permanently mounted and meet the ANSI Z87 standard. (Tinted safety glasses are not permitted unless arrangements have been made with EHSS, contact lenses are not permitted).

6.1.11 No items may be worn on or in the ears to prevent hearing alarms, announcements, unless provided by [redacted] for hearing protection. (Headphones, including radios and I-pods, are not permitted).

6.1.12 Badge holders worn around the neck must have break-away clasps. (Badge holders worn around the neck without breakaway clasps, or holders that have been modified to not break-away when caught or pulled are not permitted).

6.1.13 Ties are frequently worn by visitors and guests and are not removed in the Production areas. They are covered by a labcoat. Scarves may not be worn around the neck.

6.1.14 Safety glass holders worn around the neck must have break-away clasps, or be of the style with loops around the arms of the glasses so that they slide off if caught or pulled.

6.2 **Foot protection** – Steel toe safety shoes are required where associates are required to lift or move objects over 35 pounds. Steel toe safety shoes are also required when associates are required to lift or move objects less than 35 pounds and there is a danger of falling or rolling objects which may injury the foot, or where objects may pierce the sole of footwear.

6.2.1 [redacted] provides reimbursement for Safety Shoes once per year up to a predetermined dollar amount. Reimbursement forms and information on the program may be obtained from EHSS.

6.2.2 Reimbursement for safety shoes may be provided more frequently, depending on wear on the safety shoes and job requirements, at the discretion of management or EHSS.

6.3 **Eye protection** – General safety glasses, including safety glasses that are worn over prescription glasses are provided to [redacted] associates, temporary associates, interns, co-ops, contractors, visitors, or other guests at no charge.

6.3.1 Associates cannot wear contact lenses when working in production areas.

6.3.2 Safety glasses may be obtained from the receptionist, or EHSS.

6.3.3 [redacted] provides reimbursement for Prescription Safety Glasses up to a predetermined dollar amount once per year. Reimbursement forms may be obtained from EHSS.

6.4 **Hand protection** – Protection for hands is required where hands are exposed to hazards such as skin absorption of harmful substances, severe cuts or lacerations, punctures, chemical burns, thermal burns, or extreme temperatures. PPE required for hand protection is documented in a specific job instruction, process specifications, or PM instruction.

6.5 **Head protection** – Head protection is required when there is a potential injury to the head from falling objects. Head protection is required in areas where construction or overhead work is being performed. Areas requiring head protection shall be isolated and signed to warn of the head protection requirements.

6.6 **Fall protection** – PPE or fixed guarding is required when there is a potential injury due to falling when work is not being performed on ground level. Safety markings harnesses, guard rails, ropes, or other guarding and PPE may be required to protect against injury from falling. Fall protection must be designed into building changes and additions, as well as into new or modified equipment or machines, and be included in the work instructions, process specifications, or PM instructions in those areas.

6.7 Additional PPE – Additional PPE may be required as a result of a hazard review of new or modified machines and equipment. The additional PPE requirements are documented in a specific job instruction, process specifications, or PM instruction.

6.8 Discipline – Any disciplinary action that is required due to violations of this procedure must be addressed by management according to Human Resources Corrective Action Policy ([redacted]).

7.0 Training

7.1 Orientation – All Associates, temporary Associates, co-ops, service contractors and interns are trained in the general dress code and PPE requirements on their first day at [redacted] in the EHSS Orientation.

7.2 On The Job - All Associates, temporary Associates, co-ops, and interns are trained on the specific PPE requirements for the job during On the Job Training by their manager. On The Job Training includes training on the specific work instructions, process specifications, or PM's where additional PPE is required.

7.3 Contractors and Guests

7.3.1 Escorted

7.3.1.1 When escorted by an [redacted] associate, contractors and guests must be verbally trained in the dress code and PPE requirements before they enter an Affected Area of this procedure. It is the responsibility of the [redacted] associate to escort and ensure the contractor or guest is complying with the dress code and PPE requirements.

7.3.1.2 Contractors and guests who stay within designated tour aisles in an affected area need only safety glasses as long as they do not cross the taped aisle line.

7.3.2 Non-escorted– All contractors and guests that may work on their own in an Affected Area of this procedure must be trained in the dress code and general PPE requirements and work area requirements. This training can be completed by either attending orientation training, training by the associate managing them while they are onsite, or before they begin work in an Affected Area. If additional PPE is required, the associate managing the contractor or guest must train them in the additional work instruction, process specification, or PM instruction.

8.0 Records

8.1 Orientation – EHSS maintains all orientation training records in the EHSS files.

8.2 On The Job – Training associated with a specific work instruction, process specification, or PM instruction is maintained with the specific document.

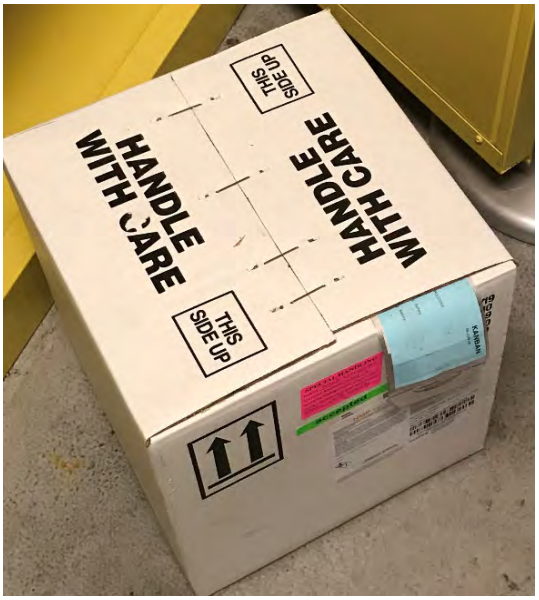
9.0 Yellow Line Procedures

9.1 Yellow Lines in [redacted] – Associates who stay within designated yellow tour aisles in wet space and capacitor areas need only safety glasses as long as they do not cross the taped aisle line. They are not required to remove jewelry or wear lab coats.

10.0 Receiving Inspection and Shipping and Receiving - Associates located in receiving inspection and the shipping and receiving areas are expected to meet all guidelines set forth under section 6.0 with the exception of 6.1.7, 6.1.9, and 6.3 while in their specified work area.

Attachment C

Examples of Small Container NMP Shipments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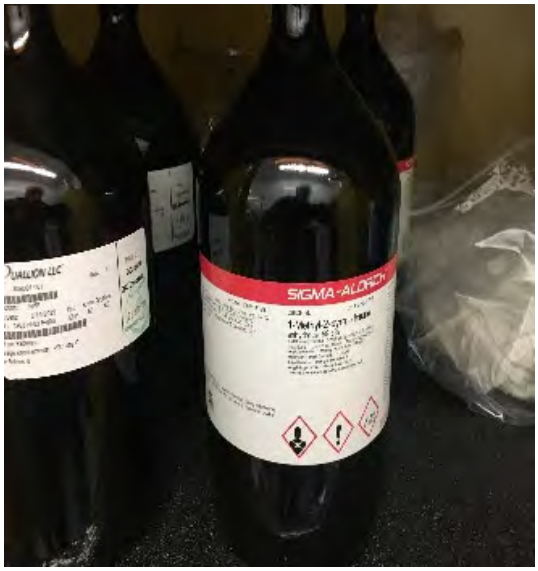
SIGMA-ALDRICH

Attachment D

Examples of NMP Waste Drums Used in Small Operations

Example of drum containing NMP waste after controlled transfer from small container:

Example of drum containing sealed small containers of NMP waste: